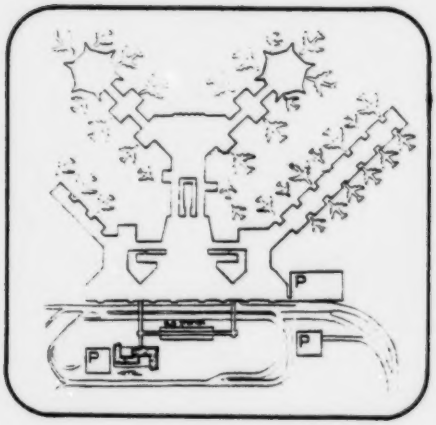
TP 8291E

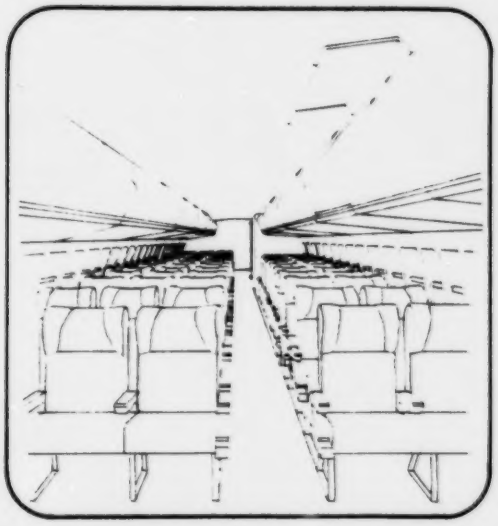
REVIEW OF EMERGENCY EVACUATION PRACTICES FOR ELDERLY AND DISABLED PASSENGERS FROM VEHICLES AND TERMINALS

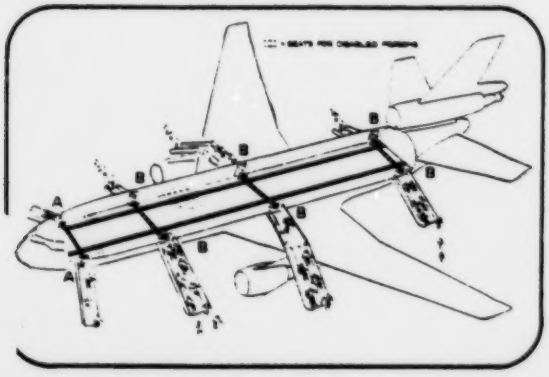
Prepared for the
Transportation Development Centre

by TransVision Consultants Ltd.

March 1987







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17. Abstract

The objective of this study was to identify and assess alternative methods for the safe and timely evacuation and rescue of elderly or disabled passengers from transportation vehicles and terminals. Standard methods are not always effective for these passengers because of their physical or mental condition or their inability to manage self-evacuation. Vision-impaired travellers often are not aware of the location of emergency exits and emergency safety procedures. Hearing-impaired travellers are often unaware of warning signals/messages provided over the public address system. Mobility impaired travellers have difficulties negotiating stairs.

This study outlines methods, procedures, and technologies of evacuation and rescue as a function of the environment in which they operate. Equipment needs are ascertained and recommendations made regarding database development, familiarity and simulation training, standardizing operating procedures, debriefing of accident victims, and developing evacuation and mobility aids.

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17. Résumé

Cette recherche avait pour objet de trouver et d'évaluer de nouvelles méthodes d'évacuation des voyageurs âgés ou handicapés d'un véhicule de transport en danger ou d'un terminus menacé qui soient mieux adaptées à cette catégorie de voyageurs. Les méthodes couramment utilisées ne sont pas toujours efficaces, du fait de l'incapacité physique, sensorielle ou mentale de ces voyageurs et de leur manque d'autonomie. Les voyageurs souffrant de handicaps visuels ne peuvent pas repérer les issues de secours, ceux qui souffrent de handicaps auditifs ne se rendent pas compte des messages et des avertissements diffusés sur le système de sonorisation; quant aux voyageurs à mobilité réduite, ils ont de la difficulté à utiliser les escaliers.

L'étude propose des méthodes, des procédures et des matériels d'évacuation et de sauvetage adaptés au milieu environnant. Elle définit les besoins en matériels spécialisés et formule des recommandations en ce qui concerne les bases de données, la simulation de situations d'urgence et la formation des agents d'intervention, l'interrogation des victimes d'accident et l'étude des aides à l'évacuation et à la mobilité.

18. Mots-clés	19. Diffusion
Transports collectifs, handicapés physiques, personnes âgées, invalides, évacuation, secours.	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

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SUMMARY

Standard methods for evacuating passengers from transportation terminals and vehicles are not always effective for elderly and disabled passengers because of their physical or mental condition or their inability to manage self-evacuation. Vision-impaired travellers often are not aware of the location of emergency exits and emergency safety procedures. Hearing-impaired travellers are often unaware of warning signals/messages provided over the public address system. Mobility-impaired travellers have difficulties negotiating stairs.

Recognizing the need for evaluation of existing practices for terminal and vehicle evacuation, the Transportation Development Centre commissioned a study to investigate the problem. The objective of the project was to identify and assess alternative methods that could be used to ensure the safe and timely evacuation and rescue of elderly or disabled passengers from transportation vehicles and terminals.

To satisfy the objective, the literature was reviewed, organizations undertaking studies in the area were contacted, knowledgeable individuals in the industry were interviewed, suppliers of emergency alarms and systems were surveyed, emergency procedures, techniques and systems were reviewed, and rules and procedures for emergencies were examined.

The interrelationships between the passenger characteristics, the transportation facility, the emergency-causing incidents, and the evacuation techniques and systems were investigated and used as a context for the discussion of emergency practices. The result is a description of alternative emergency measures, systems, procedures and technology. The main thrust is to assess the use of technology to help the elderly and disabled to cope with a threat to their safety.

The study outlines alternative methods/procedures/technology of evacuation and rescue as a function of vehicle and terminal characteristics. Equipment needs are ascertained and suggestions are made for developing a better data base, for providing familiarity and simulation training, for developing standard operating procedures, for debriefing actual accident victims, and for disseminating newly-developed technology.

Based on the information presented, recommendations are presented and are summarized below in order of priority. The recommendations are relevant to the following:

- Investigations, research, and information-generating activities to provide a better data base by mode for future planning, decisions, and actions.
- Research and testing to establish the effective range of visible alarm signals and the best audible signal(s) for warning the largest number of people with hearing impairments.
- Research and testing to develop clearly-understood voice alarm systems in conjunction with visible textual alarms for use in any transportation terminal or vehicle.
- Human factors research and analysis of initial safety orientation information for travellers with respect to means of presentation, format and content of the message.
- Human factors research and analysis of emergency communication systems and devices which would allow for emergency notification, provisions of instructions and information, and summoning assistance.
- Improvement of education and training, particularly as it relates to instructional manuals and background materials for both the individual disabled persons, and for those who will be called upon to aid them.
- Investigation of evacuation routes and refuge areas to facilitate prompt exiting of all persons from areas of immediate danger to refuge areas and eventually to areas of permanent safety, including the development of important concepts involving the degree of redundancy of egress paths and staging areas.
- Pre-planning and development of emergency plans for transportation systems as relates to the individual, the management of transporation services, and other related emergency response organizations.
- Development of codes and standards for elderly and disabled persons as integral parts of general life safety provisions in building, fire and other safety codes. There should be no separate life safety codes and standards for disabled persons.

SOMMAIRE

Les méthodes couramment utilisées pour évacuer les passagers d'un véhicule en danger ou d'un terminus menacé ne sont pas toujours efficaces lorsqu'il s'agit de personnes âgées ou de handicapés, en raison de leurs capacités physiques, sensorielles ou mentales diminuées et de leur manque d'autonomie. Les voyageurs souffrant de handicaps visuels ne peuvent pas repérer les issues de secours, ceux qui souffrent de handicaps auditifs ne se rendent pas compte des messages et des avertissements verbaux diffusés sur le système de sonorisation; quant aux voyageurs à mobilité réduite, ils ont de la difficulté à utiliser les escaliers.

Devant les lacunes des méthodes actuelles, le Centre de développement des transports a financé une étude visant à rechercher et à évaluer des méthodes mieux adaptées à cette catégorie de voyageurs.

Pour cela, une recherche documentaire a été faite, et des entreprises et des spécialistes dans le domaine concerné ont été contactés et interviewés; une enquête a été lancée auprès des fournisseurs de systèmes d'alarme; enfin, les méthodes, techniques et dispositifs d'utilisation courante ont été passés en revue, ainsi que les procédures en vigueur.

Les caractéristiques propres aux voyageurs, aux véhicules et aux terminus, les causes de danger et leur nature ainsi que les procédures d'évacuation et les techniques d'alarme ont été mises en rapport les unes avec les autres et les interactions décelées utilisées comme toile de fond de la recherche. Celle-ci a débouché sur une approche nouvelle concernant les mesures à prendre, les procédures à suivre, les dispositifs à utiliser et les technologies à mettre en oeuvre. Ce sont surtout ces dernières qui ont fait l'objet d'une évaluation approfondie visant à en déterminer la contribution au résultat recherché.

L'étude propose de nouvelles méthodes, procédures et technologies d'évacuation et de sauvetage en rapport avec les caractéristiques des véhicules de transport et des terminus considérés. Elle définit les besoins en matériels spécialisés et formule des recommandations en ce qui concerne: le développement de la base de données pouvant servir à la simulation de situations d'urgence et à la formation des agents d'intervention; la mise au point de procédures standard et de méthodes d'interrogation des victimes d'accident et, enfin, la diffusion des technologies nouvelles.

Ces recommandations sont récapitulées ci-dessous par ordre de priorité:

- Lancer des actions de recherche, d'enquête et de documentation permettant d'améliorer la base de données sur tous les modes de transport afin de faciliter la planification, la prise de décisions et la mise en oeuvre de celles-ci.
- Déterminer, par la recherche et les essais, la gamme des signaux visuels et auditifs les plus efficaces permettant d'alerter le plus grand nombre possible de voyageurs souffrant de handicaps auditifs.
- Rechercher, essayer et mettre au point des dispositifs lançant des alarmes vocales faciles à comprendre et des signaux visuels bien clairs, pouvant servir dans les véhicules de transport et les terminus.
- Analyser, sur le plan ergonomique, et quant au format, au contenu et à la présentation, l'information en matière de sécurité destinée aux voyageurs.
- Analyser, sur le plan ergonomique, les dispositifs d'alarme destinés, d'une part, à alerter, informer et orienter les voyageurs et, d'autre part, à lancer des appels de secours au besoin.
- Améliorer les techniques et matériels de formation, notamment les manuels et brochures destinés tant aux voyageurs handicapés qu'aux agents chargés de les aider.
- Trouver les itinéraires susceptibles d'accélérer l'évacuation des zones dangereuses et menant à des aires de refuge provisoires, en attendant l'évacuation vers des zones plus sûres, et mettre au point des concepts importants, telle la redondance des itinéraires d'évacuation et des aires de rassemblement.
- Etudier des codes et des règles de sécurité et de prévention dans..les immeubles, les véhicules de transports, les terminus, etc., qui intègrent dans une même procédure les secours portés aux personnes âgées et aux handicapés ainsi qu'aux autres personnes, sans distinction aucune.

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1. INTRODUCTION

Standard methods for evacuating passengers from transportation terminals and vehicles are not always effective for elderly and disabled passengers.

Standard evacuation methods are not always effective due to the physical or mental condition or the inability to manage self-evacuation of elderly and disabled passengers. Vision-impaired travellers often are not aware of the location of emergency exits and emergency evacuation procedures. Hearing-impaired travellers may be unaware of warning signals/messages provided over the public address system. Mobility-impaired travellers may have difficulties negotiating stairs.

Recognizing the need for evaluation of existing standard practices for terminal and vehicle evacuation, the Transportation Development Centre commissioned this study to investigate the problem. The objective of the study was to provide an overview of alternative methods that could be used to ensure the safe and timely evacuation and rescue of elderly or disabled passengers from transportation vehicles and terminals.

To satisfy the objective, the literature was reviewed, organizations undertaking studies in the area were contacted, knowledgeable individuals in the industry were interviewed, suppliers of emergency alarms and systems were surveyed, and various transportation personnel were contacted with respect to existing emergency procedures, techniques and systems.

The interrelationships between the passenger characteristics, the transportation facility, the emergency-causing incident, and the evacuation techniques and systems were investigated and used as a context for the discussion of emergency practices.

The result is a broad overview of alternative emergency measures, systems, procedures and technology. The main thrust is to assess the use of technology to establish a transportation environment in which the elderly and disabled can better cope with a threat to their safety.

2. FACTORS

The factors involved in life safety considerations are discussed in this chapter. The term 'life safety' is used to differentiate the topic of discussion from other safety considerations in transportation such those that may occur for the protection of vehicles and equipment. For example, an airplane may have many safety features like radar and collison avoidance systems to ensure that safe flight is provided but these are not considered in this report. This report is only concerned with those aspects that are directly related to the protection of human life in an emergency situation.

'Life safety' is a term used in building codes and related literature to denote this concern for the protection of human lives in emergencies. A life safety system consists of alarm and control systems, communication systems, evacuation devices, construction features, facilities maintenance, evacuation planning, and training designed to protect the lives of people in emergency situations, such as may occur with fire, flood, explosions, earthquake, collisions, terrorist activities and bomb threats (1).

A life safety system consists of pre-event and post-event activities. The principal pre-event activities include construction design and materials, facilities maintenance, evacuation planning, and training. The principal post-event activity is evacuation or removal to a place of refuge. Some pre-event activities such as evacuation planning and practice can greatly facilitate post-event activities such as successful egress in an emergency.

A life safety system also includes devices, such as warning alarms and communication aids; but it is quite incomplete when only devices are considered. Thus, egress for wheelchair users and other persons with mobility impairments is not directly an issue of alarms and communication, but for alarms to have their desired effect, such egress must be assured.

A life safety system for elderly and disabled passengers in transportation vehicles and terminals in emergencies requires an interactive approach involving interrelationships among: the passengers (both able-bodied and disabled), the facilities (including construction, protection devices and systems), and the measures (including emergency planning, staff training, fire departments and rescue services). Thus, there is a need for a total systems approach to life safety problems faced by the elderly and disabled.

SYSTEMS CONSIDERATIONS

In addition to the nature of the emergency, three factors come into play in developing emergency evacuation measures for elderly and disabled passengers from transportation vehicles and terminals: the characteristics of the **passenger**, the type of **facility** available, and the emergency **measures** and practices. Exhibit 1 illustrates these interrelationships.

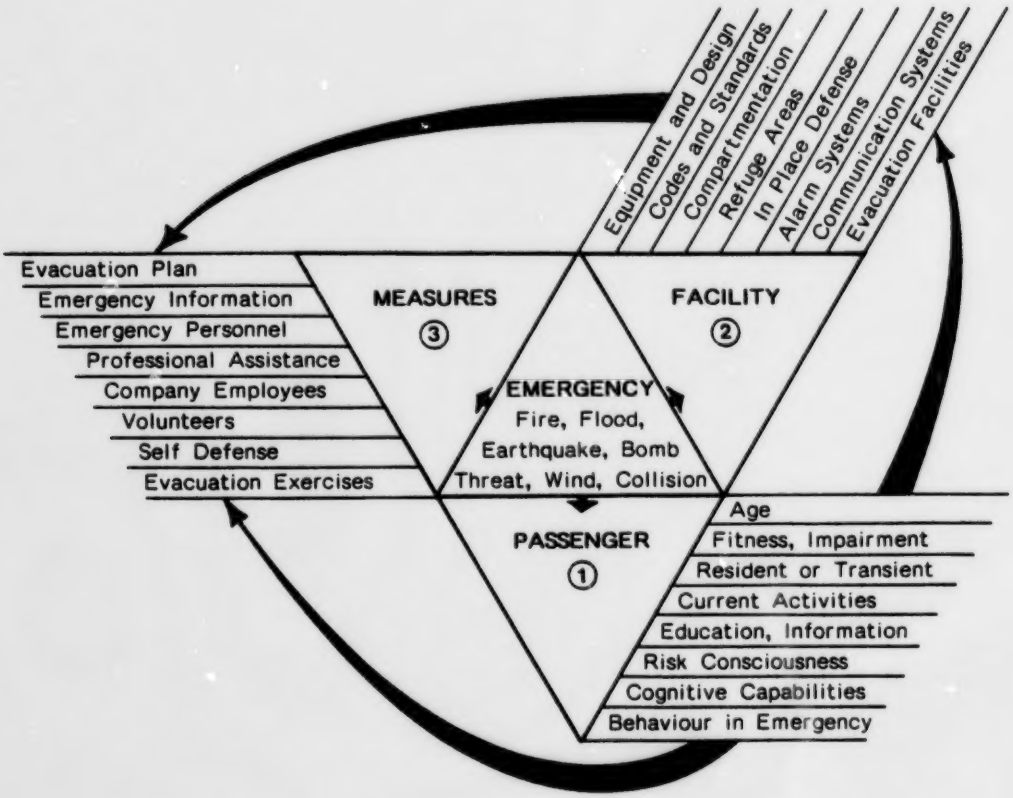


Exhibit 1: Interrelationship of Emergency Factors

The emergency-causing incident may be a result of fire, flood, earthquake, wind, collision, chemical or toxic spill, bomb threat, or terrorist activity. Emergencies, by their very nature, are events that cannot be dealt with by ordinary methods or routines. They cause a threat to human life and life safety systems are needed to protect individuals in the face of this threat.

The **passenger** characteristics such as age, mental and physical condition, education, assimilated information and applied experience influence the requirements and design of equipment and facilities so that they can act for their own safety and assist others.

The **facilities** hold and protect their contents and the human activities inside. In their design and structure, transportation facilities -- vehicles and terminals -- incorporate detection, alarm and notification, communication, evacuation and safe refuge systems for emergency situations.

The **measures** developed must be related to the passengers' activities and to their mental and physical abilities. These measures/practices used in an emergency often require apparatus, equipment, systems, and other aids as well as personnel training, management planning and emergency simulations.

Characteristics of the facility (vehicle or terminal) and its life safety provisions affect the size, type and intensity of the emergency threat. The provision of protection systems to enable disabled persons and other persons to escape from a hazard to an area of safety determines the probable consequences of the threat. Systems within the facility and measures to use those systems interrelate with the passengers and transportation personnel to alleviate the consequences of the threat by ensuring that each individual is aware, understands and can take actions which they are capable of to provide for their own safety as well as the safety of others.

All emergency evacuation systems research, planning and practice should therefore consider all the factors of an emergency situation (the cause of the emergency, the passengers, facilities, and measures) in relation to the human factor, especially as applied to elderly and disabled persons.

3. PASSENGERS

The travelling population is composed of a multitude of people with different abilities and disabilities -- for each mental or physical function required in travelling, there is a range of ability to perform, with some individuals performing superlatively, some minimally or not at all, and some at every level in between. Variations also occur in equipment and systems for minimizing functional limitations.

The travelling population still encounters many barriers in the nation's transportation systems in one form or the other. These barriers are not limited to the elderly and disabled population, but are also handicapping to able-bodied individuals. Children and visitors can have perceptual difficulties. Pregnant women, the arthritic and aged can have mobility problems. Anybody can be temporarily injured in an emergency situation and have unexpected difficulties.

Barriers need not be architectural; they can be social (language), economic (excess costs), perceptual (incomprehensible symbology), sensorial (not able to be seen, heard or felt), attitudinal (prejudice), informational (misrepresentation), etc. In the transportation environment, these barriers are compounded by other factors: acceleration and deceleration, crowd movement, time pressures, information pressures, long walking distances, and waiting in lines.

Thus, we need to consider the entire spectrum of needs in assessing systems and measures for emergency evacuation from transportation vehicles and facilities.

FUNCTIONAL CONSIDERATIONS

The following exhibit lists the major (but not all) functional considerations to be taken into account in assessing emergency evacuation systems. These functional considerations are related to specific disabilities and then to systems and measures which would help to mitigate any difficulties that might evolve from using emergency evacuation systems.

Functional Considerations	Lack of Ability to:	Life Safety System Considerations
Mobility	Move or propel oneself horizontally or vertically	Safe area refuge must be close by or quickly transported in order to meet a four-minute building and 90-second vehicle 'rule of thumb' smoke environment survival time requirement.
Agility	Physically operate controls of various kinds	All controls must be extremely simple and operable by gross motor activities only; all controls within 40 inches above the floor.
Hearing	Detect and follow audible alarms and instructions	Provide visual and tactile alarm systems.
Sight	Detect alarms and follow visual instructions	Provide audible and tactile alarms and instructions.
Perception, Cognition	Mentally understand controls and instructions (through differing languages, lack of education, presence of learning disabilities, mental disability)	Provide non-language specific instruction and control directions, use clearly understandable symbolic instructions and psychologically appropriate control instructions (i.e. in an emergency, a person wants to push on a door to get out, not pull on it).

Exhibit 2: Functional Considerations

Mobility limitations vary from the slow walking and climbing of the elderly, through the use of canes and crutches to the wheelchair user (which are very important considerations since speed is the essence in evacuation). Agility limitations relate to manipulative dexterity; particularly, opening and closing doors. Communications-impaired individuals can have a combination of vision, speech, hearing or cognitive disability. One-way communication can often be unimpaired while two-way communication is difficult; that is, the person may comprehend information but can not communicate their concerns. Therefore, warning and orientation information must be in a multi-media format.

To provide an illustration of the varying abilities of passengers, Exhibit 3 is presented on the following page. This Exhibit illustrates the range of mobility functional limitations that was considered in a study by the Civil

Aeromedical Institute for the United States Federal Aviation Administration on the emergency escape from airplanes of disabled air travellers (2).

TABLE 4. Rate of Movement Through the Aisle

Impairment or Cause of Impairment	Number of Subjects	Average Rate of Movement (ft/s)	Range (ft/s)
Neurological			
Blindness	21	3.29	0.60 - 5.79
Deafness	5	4.65	1.49 - 8.21
Mental Deficiency	21	3.68	1.29 - 8.37
Neuromuscular			
Cerebral Palsy	7	1.59	0.42 - 5.49
Old Age	10	3.59	1.30 - 5.27
Paraplegia and Quadriplegia	20	1.58	0.70 - 4.18
Hemiplegia	14	1.00	0.20 - 2.61
Muscular Dystrophy, Multiple Sclerosis, and Polio	7	2.42	0.78 - 7.29
Orthopedic			
Arthritis	5	3.02	2.28 - 4.29
Arm Cast	2	6.25	5.60 - 6.89
Lower Leg Cast and Amputee	3	2.38	1.89 - 2.95
Congenital Birth Defects	5	2.81	1.40 - 4.65
Other			
Obesity	9	3.91	1.89 - 8.37
Unimpaired	24	8.01	3.00 - 10.05

SOURCE: Emergency Escape of Handicapped Air Travellers, FAA

Exhibit 3: Some Functional Characteristics

Estimating the number of Canadians with functional limitations depends upon the source of the data and the basic assumptions (3). Acceptable estimates, however, from the Canadian Health and Disability Survey indicate that 12.8 percent of all Canadians are disabled in some manner --

1.6 million mobility impaired,
1.3 million agility impaired,
0.3 million visually impaired,
0.6 million hearing impaired,
0.1 million speech impaired, and
83,000 with a mental disability.

BEHAVIOURAL CONSIDERATIONS

Contrary to popular belief that panic prevails in emergencies, human behaviour in an emergency is generally altruistic and characterized by expanded citizenship and increased mutual support as a realization of the importance of preserving life (4). Refutation of the frantic 'everyone for themselves' attitude in an emergency has significant ramifications for the well-being of the elderly and disabled in a transportation emergency. They will neither be left behind nor trampled underfoot. The scenario of panic, flight, selfish behaviour, and incapacitating shock during an emergency is a myth. Building egress during fires, for example, has been shown to be at a slow steady pace which masks the difference in individual ability (5).

Human behaviour shows a history of being able to deal with problems. This attitude and behaviour of coping prevails during an emergency situation -- especially when it is reinforced by concise, reliable information both before and during the emergency. The natural inclination of most persons on hearing an alarm or detecting a threat is to search for more information. Variations in the appropriate response cause people to immediately ask for directions first. There are many cases, however, where even the most able-bodied person delayed too long. To adequately deal with problems and successfully contend with the potential threat, especially for disabled persons, who may move slower or be unable to evacuate without assistance, concise, reliable and understandable information is a prerequisite.

The deaf or severely hearing impaired may need communication from another person using sign language or visual signs. Even for those without communication problems, the standard alarm is a poor source of information about an emergency. Much valuable time can be lost trying to get more detailed information. Too many questions arise ... Is it a real emergency? ... Is evacuation required? Disabled persons can not afford the time to search for answers to these questions.

Closely related to a person's ability to cope with adversity and their need for information is their attitude toward risk-taking. The acceptance of the factors which constitute personal risk inherent in travelling depends upon the attitude of the individual and the nature of their disability. This 'self-determination', however, can only be socially acceptable when sufficient information is available for the traveller to weigh the consequences (the potential hazard to other travellers in an emergency) and avoid or accept the freedom of movement.

This self-determination of travel, however, does not relieve Transport Canada from its duty to minimize the risk of injury and mental trauma to all passengers. The Canadian Airline Flight Attendants Association have stated "it is morally offensive to provide equal access to air travel without at the same time ensuring equal access to emergency evacuation" (6).

4. FACILITIES

Transportation facilities consist of a wide variety of vehicle types -- such as buses, rail cars, ferries and airplanes -- and terminals where passengers transfer between different vehicle types. Passengers on-board vehicles are usually restricted in their movements and rely on the transportation personnel on-board the vehicle for safety information and directions. Passengers in a terminal, on the other hand, are expected to take fairly independent action in response to emergency alarms and directions. The two situations -- vehicles and terminals -- are entirely different. And it is difficult to cover each mode and each type of terminal adequately in an overview report such as this.

Within each, however, codes and standards have been developed over time that specify equipment and design for life safety. In Canada, the National Building Code of Canada applies to federal buildings. In the United States, there are four model building codes as well as the NFPA 101 Life Safety Code (National Fire Protection Association). In the United States in recent years, there has been a major effort to bring closer together the requirements of the model building codes and the Life Safety Code, especially those requirements dealing with egress. In Canada, life safety concerns of disabled persons are just being introduced into building standards for airport buildings (7), principally with respect to egress and refuge areas.

Codes and standards for transportation vehicles, however, may transcend jurisdictional boundaries and changes to present policies may have to come at different levels of government. For this reason, the responsibilities of the three levels of government are outlined in the following paragraphs to assist those unfamiliar with the sometimes complicated division of powers which is an inherent feature of the Canadian constitution.

TRANSPORTATION VEHICLES

Generally, transportation vehicles have cramped conditions for seating and movement. Space is at a premium, hence seats are closely spaced and aisles are narrow. Mobility is drastically reduced in any incident, such as a vehicle leaving the road, which results in a non-horizontal floor. Further, bus transit and paratransit vehicles usually have only a single operator who could be incapacitated as a result of a collision leaving no able-bodied person capable of evacuation until external help arrives.

In the transportation vehicle -- especially aircraft and ferries -- the passengers are not expected to take independent action during an emergency. Only the crew has the knowledge and experience to deal with the situation. Passengers are informed using the public address system or other means but trained crew members are responsible for crowd control and organizing the appropriate passenger activity. Therefore, the alarms are meant to inform only the crew and are usually coded with no concern for standardization.

Road Vehicles

The 1971 Motor Vehicle Safety Act gave responsibility to the federal government for setting safety standards for new vehicles at the point of manufacture or entry from abroad, but once a vehicle has left the original manufacturer, even if it moves immediately to be retrofitted for disabled passengers, safety usually becomes a provincial responsibility. In addition, operation/regulation of urban buses has been delegated to municipalities.

Road vehicles -- transit buses, highway coaches and small paratransit buses -- present difficult evacuation problems. In addition to lack of safety orientation information, closely spaced seats, narrow aisles and a high probability of non-horizontal floor, the basic vehicle designs hinders evacuation. In addition to the regular exits, coaches provide a knock-out roof mounted hatch and top-hinged side windows to provide extra escape routes. The window exits are difficult to open from the outside, require a high step-over height from inside the bus, have a long drop to the ground and are difficult to hold open due to the weight of the glass. But their weight and strength ensures a high degree of structural integrity in the case of collision. Paratransit buses are often standard vans modified by widening and extending the bodies, and raising the roofs to increase passenger load and comfort. These bodies and roofs reduce the structural integrity of the van so that roof collapse and body deformation jams the doors. The very devices such as power wheelchair lifts that make paratransit useful also totally block the exits in a power failure. Bus transit and paratransit have only a single operator who could be incapacitated as a result of a collision, leaving no able-bodied person capable of evacuation until external help arrives. Heavy reliance is placed on external professional assistance in an emergency situation (9,10).

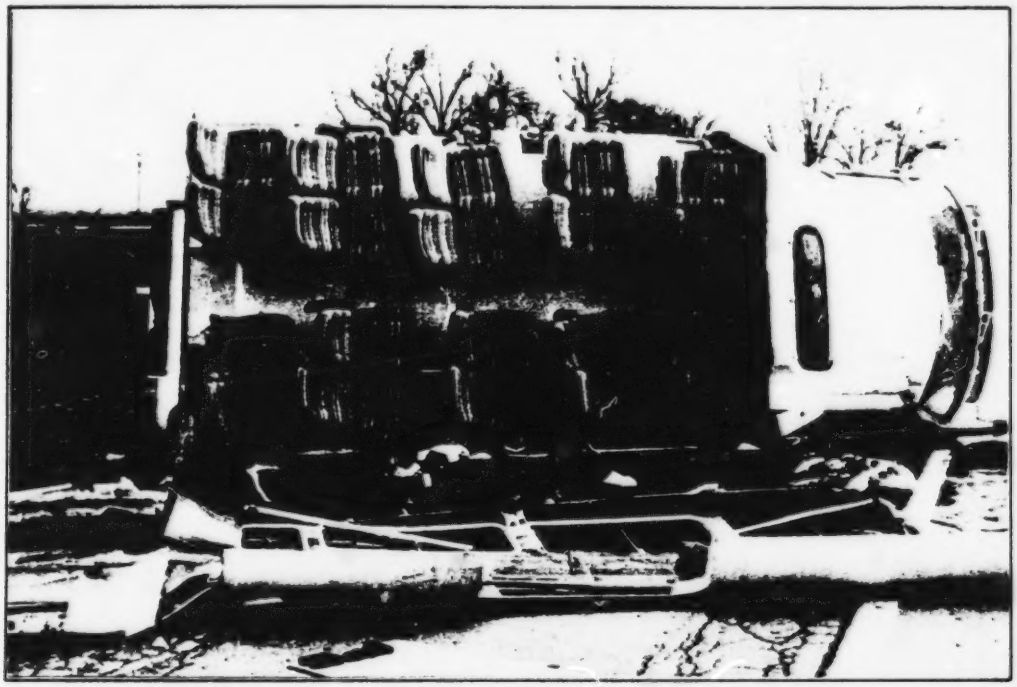


Exhibit 4: A Small Paratransit Vehicle Accident

Rail Vehicles

Intercity railway passenger service in Canada is provided by VIA Rail Canada Inc., a crown corporation created in 1977. A contract is negotiated between Transport Canada and VIA whereby Transport Canada pays VIA a subsidy for the operation of rail passenger services. As a part of this contract, VIA files its operating procedures with the Canadian Transport Commission (CTC) for approval.

Rail vehicles present other difficulties -- somewhere between road vehicles and aircraft. An emergency in a rail vehicle is one in which individual action, volunteer assistance and professional help is most advantageously combined to effect evacuation. Although no specific emergency evacuation exits or equipment is used, evacuation can be effected through the loading doors (or possibly through the windows). An underground emergency in a loaded rail transit train, however, presents a difficult emergency evacuation scenario. Heat, smoke and toxic fumes in a confined tunnel require immediate response from both company personnel and firemen because all passengers are at peril. Generally, however, underground rail transit systems have excellent alarm detection and notification systems that have been proven in realistic simulation exercises (10).

Civil Aviation

Transport Canada is responsible for the construction and operation of federally-owned airports and Transport Canada sets out the safety regulations for on-board procedures for air carriers and accepts or rejects air carrier policy as it applies in matters of safety. Air carriers develop policies and procedures for the carriage of passengers which are submitted to Transport Canada for approval of safety features and procedures as a condition for obtaining an operating certificate.

The design and interior fitting of an aircraft is primarily determined by the extremely strict safety requirements in force for aircraft construction, manufacture and use. The American Federal Aviation Administration (FAA) has issued safety regulations and directives that form the basis of the majority of other countries civil aviation regulations (11). All fuselage exits, whether or not provided with slides, are intended for use in an emergency. The number of exits and slides is based on the balance between the number of passengers, the number of personnel required for emergency evacuation and on the fact that the time required for evacuation must, under no circumstances, exceed 90 seconds.

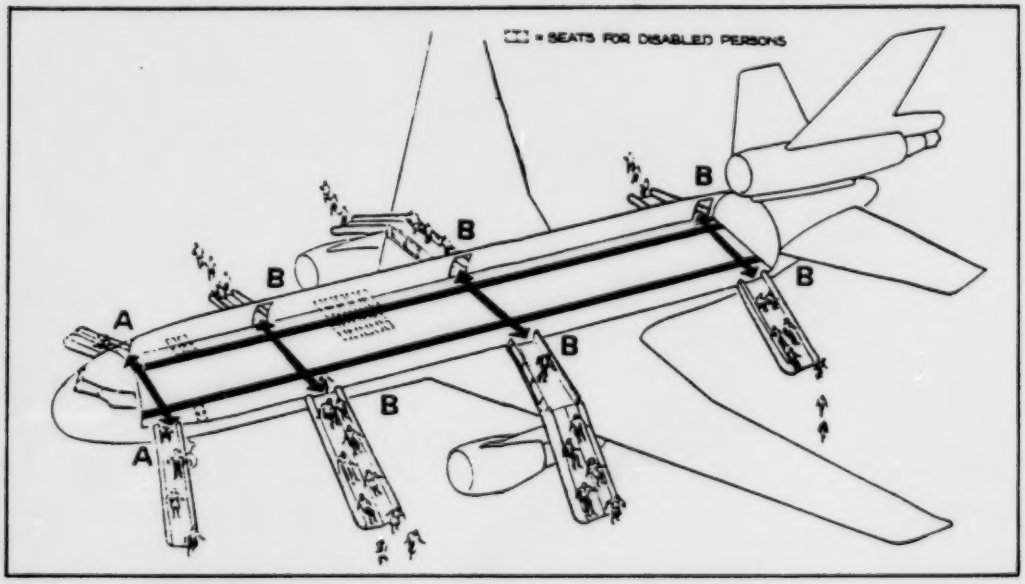


Exhibit 5: Typical Evacuation From an Airplane

When emergency evacuation takes place, it is assumed that passengers are capable of reaching the exits and leaving the aircraft without much assistance. Information briefings are provided to every passenger before every flight to inform them of the emergency procedures. Seating policies are also designed ensure the greatest safety to the most passengers.

Passenger Ferries

The general operation of ferry services in Canada is the responsibility of the operators but the safety aspects of ferry operations are regulated under the Canada Shipping Act. Assistance is provided to various ferry services on the basis of contracts between the federal government and the ferry operators or between the federal and a provincial government. Approximately ten east coast ferries are operated by CN Marine, a federal crown corporation. West coast ferry operations are the responsibility of the province of British Columbia.

Passenger ferries, like aircraft, have strict safety requirements. Modern ship design is an important factor in passenger safety. Instead of narrow corridors and many small lounges, contemporary design stresses high visibility -- no corridors and large open decks. Shipboard alarms are coded and intended to inform only the crew which are well-trained to deal with the situation. After the situation has been assessed, action initiated and the crew alerted, the passengers are informed via the public address system. Passengers are not expected to take independent action and crew members deal directly with the passengers and personally guide their actions. Coast Guard guidelines are used by ferry corporations for safety design and equipment (e.g., abandoning ship must be accomplished in 30 minutes).

TRANSPORTATION TERMINALS

In Canada, the National Building Code of Canada applies to federal buildings. Other transportation terminals are covered by the applicable provincial building codes. In Canada, life safety concerns of disabled persons are just being developed and introduced into building standards for airport buildings (7), principally with respect to egress and refuge areas as described in the 1985 National Building Code. In response to the June 1982 report of the Special Parliamentary Committee on the Disabled and the Handicapped (12) and the provisions of the Canadian Charter of Rights Transport Canada has gone through several iterations to develop accessibility standards and these are expected in 1988. Operational procedures, such as preparation of fire safety plans and designation of floor monitors to assist disabled persons, are outlined by the Fire Commissioner of Canada.

Terminals are generally low-rise buildings designed with large open spaces and high capacity access to accommodate passenger surge loads. The open-plan design can be particularly advantageous to the elderly and disabled because the flat floor areas maximize the utility of mobility aids and thus minimizes the need to provide safe-refuge areas for the mobility limited. Vertical movement is always a concern, but only one or two flights of stairs need be negotiated. Safety guidelines for emergency situations are spelled out in the National Building Code which has considerations for barrier-free design, refuge areas, alarms and equipment.

Warning Systems

Warning systems

3.7.3.17.(1) To assist persons with a hearing impairment, when a fire alarm system is required by Subsection 3.2.4. or Subsection 9.10.18., a warning system conforming to Sentences (2) and (3) shall be installed in locations described in Articles 3.7.2.29. to 3.7.2.33., except as provided in Sentence (4).

(2) The warning system required by Sentence (1) shall consist of strobe lights supervised, activated, and powered by means of the *accepted* fire alarm system (supervised by the fire alarm system shall mean up to, but not include, the strobe lights), and be connected to, activated, and powered by, the sounding of the *smoke alarm* and

(a) be of 7 watt second output capacity and produce approximately 80 flashes per minute,

(b) have a clear or white translucent lens,

(c) have the word "FIRE" clearly visible on the lens or attached nameplate,

(d) be installed in each bedroom, room closed off from the living area by a door except a bathroom, and living area or hallway serving the living area, and

(e) be located minimum 2150 mm above the floor on a wall or ceiling in a location that will maximize effectiveness.

(3) When the strobe lights described in Sentences (2) and (5) are activated by the *smoke alarm*, a separate small indicator light shall be activated and shall be located either immediately adjacent to the strobe lights and clearly identified as "SMOKE", or on the *smoke alarm*, or immediately adjacent to the *smoke alarm*.

(4) When a fire alarm system is not provided in *occupancies* required by Subsection 3.7.2. to have a warning system, *smoke alarms* required by Sentence 3.2.4.8.(1) and Article 9.10.19.1. in such *occupancies* shall be provided with strobe lights, in locations described in Articles 3.7.2.29. to 3.7.2.33. as requiring a warning system, which shall

(a) be connected to, and activated by, the sounding of the *smoke alarm*,

(b) be of 7 watt second output capacity and produce approximately 80 flashes per minute,

(c) have a clear or white translucent lens,

(d) have the word "SMOKE" clearly visible on the lens or attached nameplate,

(e) be installed in each bedroom, room closed off from the living area by a door except a bathroom, and the living area or a hallway serving the living area, and

(f) be located minimum 2150 mm above the floor on a wall or ceiling in a location that will maximize effectiveness.

Areas of Refuge

Areas of refuge

3.7.3.27.(1) Every *floor area* described in Clause 3.7.2.5.(1)(e) shall have at least two separate paths conforming to Articles 3.7.3.6. to 3.7.3.10. located so as to provide different directions of travel to one or more areas of refuge as described in Sentence (2).

(2) Areas of refuge shall be

(a) an exterior *exit* door providing *access* to an *acceptable* open space,

(b) a *horizontal exit*,

(c) *floor areas* or parts of *floor areas* conforming to Clauses 3.2.6.2.(5)(d), (e), and (f), or

(d) a vestibule or corridor served by a fire fighter's elevator and protected against fire in conformance with Clauses 3.2.6.4.(3)(b) or (c) and, in *buildings* over three *storeys* in *building height*, protected against smoke movement in conformance with Sentence 3.2.6.2.(4).

Exhibit 6: Extracts from the British Columbia Building Code

A relevant extract from the British Columbia Building Code (which is one of the more progressive building codes in Canada) is provided in Exhibit 6 to illustrate some of the life safety considerations in transportation terminal design and construction. Areas of refuge are designed as a hazard-free environment until assistance can be obtained. Such a requirement is not sufficient, however, because no area of refuge is wholly safe. Given the psychology of refuge, the presence of a perceived danger, and the existence of an alternative, it is conceivable that people would choose to leave a facility, when possible, rather than remain in an area of refuge. This would seem especially likely in a low-rise, multistory facility. A mobility impaired person might choose to evacuate a building by stairway, in order to accompany others who choose to leave.

Most of the building occupants are transients pre-occupied with their own business and are likely not familiar with the specific terminal's emergency facilities. Generally, there is no initial safety orientation for entering travellers. Terminal safety orientation and communication of emergency instructions is of concern due to the large number of transient building occupants and their high level of activity. The openness which would assist in conveying an alarm can be dysfunctional when passengers are in queues and don't want to lose their place if they can't see any potential danger.

The terminals present a different case from vehicles. Here, independent action is expected and the alarm system must notify all occupants of an emergency and should convey essential information such as instructions on what to do. To promote the quickest response, the highest degree of standardization of aural and visual alarms and emergency information announcements is desirable.

Terminal Interface

The interface between the terminal and vehicle is usually a confined and hectic environment characterized by long horizontal distances, changes in vertical plane and limited opportunities to escape. Possibly it is the most dangerous transportation location -- neither here nor there.

The interface between the terminal and vehicle was described in a Transport Canada publication (13): "In the transfer environment, barriers are compounded by moving crowds and pressure to meet schedules. Many people note that they might be able to overcome barriers if it were not for pressure to move quickly. In addition to the hazard of stationary physical barriers, there are those of acceleration deceleration crowd movement, time pressure, long walking distances, reading and hearing information dialogues and waiting in lines .... Since transfer facilities are designed to accommodate the mythical average man almost any atypical traveller exceeds the tolerances of the equipment."

5. SYSTEMS

In transportation vehicles and terminals, emergency alarm, communication and evacuation systems constitute the post-event part of a 'life safety system'. Pre-event activities include evacuation planning and training. Some pre-event activities are directly related to the success of post-event activities. The principal post-event activity is evacuation or removal to a place of refuge. Evacuation planning and practice can greatly facilitate successful egress in an emergency, especially where there is a potential or known communication barrier, such as a hearing or speaking impairment.

Although this chapter is concerned mainly with alarms, communication aids and evacuation systems, the other parts of a life safety system cannot be ignored. A life safety system includes devices such as these, but it is quite incomplete when only devices are considered. Egress paths, refuge areas, emergency personnel and evacuation planning, for example, are also a part of the system. Thus, egress for wheelchair users and other persons with mobility impairments is not directly an issue of alarms, but for alarms to have their desired effect, such egress must be assured.

Two-way communications are also an important part of life safety systems. Firstly, they may be necessary to report the emergency. Communications in support of egress, such as textual audible alarms (human voice instruction), are also a necessary component. Communication from areas of refuge and from areas adjacent to stairwells is also desirable.

In transportation vehicles and terminals, emergency alarm, communication and evacuation systems serve the general population. With the exception of personal tactile alarms, for example, devices which increases the safety of a disabled person also adds to the safety of the general population.

WARNING ALARMS

Alarm systems have the following functions: (1) Initiation and detection (automatic and manual). (2) Notification, (3) Communication (supplementary), (4) Auxiliary (e.g. recapture of elevators, shutting fans, closing fire doors). Alarm systems are designed to reach "every person who is expected to take independent action in an emergency". An alarm system schematic is shown in Exhibit 7.

The functions of emergency detection, notification and communication can be performed by: (1) Appropriate alarm systems (including smoke detectors, manual and automatic notification systems, zoned communication systems, pre-recorded messages); (2) Signage and other exit identification; (3) Personal alarm and communication devices; (4) Fire service equipment; and (5) Assistance from other travellers.

To be effective an alarm must quickly and unequivocally indicate the existence of imminent danger to the person. The traveller must both sense the alarm and understand its meaning. Further, the nature of the alarm must not hinder resulting action (14).

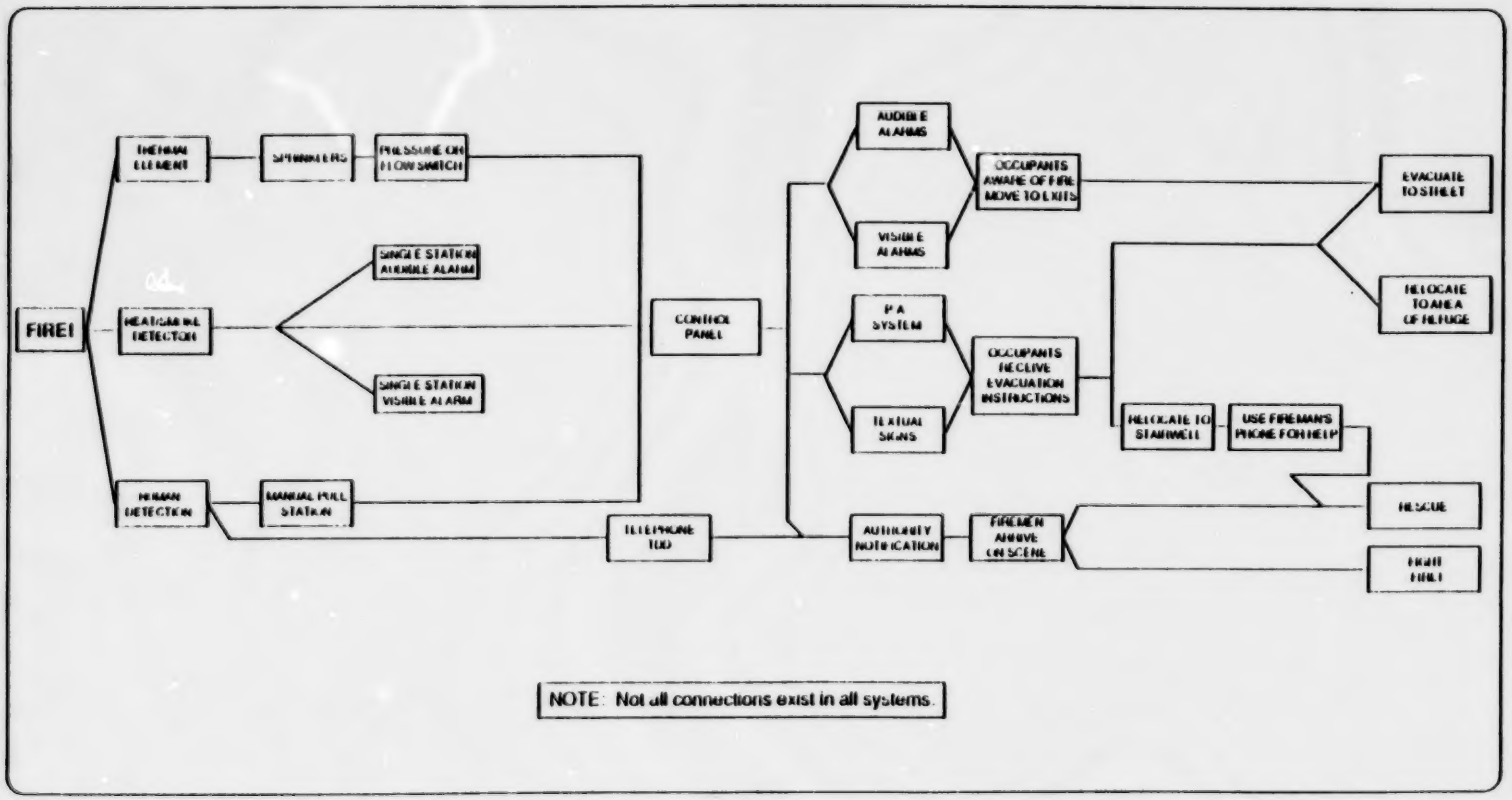
An alarm sounding in a terminal presents a complex problem because it doesn't necessarily motivate the occupants to emergency action. Because false alarms are common, people waiting in a queue may decide not to lose their place in line. The architecture of large open spaces may build a false sense of security. People feel that they can see any problem in enough time to evacuate hence don't quickly respond.

A simple ringing bell doesn't convey enough information to gain confidence and ensure initial evacuation response. This issue involves:

- the education of the travelling public as to the meaning of emergency signals, what to expect and what to do; and
- conveying enough information to each occupant to ensure their decision to act. This decision is critical to the elderly and disabled where reduced chances of escape are weighted against the potential injury of an unnecessary emergency evacuation.

Audible Alarms

Audible signalling devices use sound to impart a warning. Sound intensity is subject to regulation, ranging from 75 to 120 dBA, measured ten feet from the source of the signal. There are no standards for the frequency (cycles per second) of the signal. An audible alarm (see Exhibit 8) may be a bell, horn, siren, buzzer, electronically generated tone, etc. There appears to be no research or consumer labelling to help persons with visual or hearing impairments to select an alarm signal sufficient for their needs.



SOURCE: "Alarms Documentation Project" by Applied Concepts Corporation, 1986.

Exhibit 7: Schematic of an Alarm System

Research on effectiveness of audible alarms seems to have been limited to persons with normal hearing. Most transportation terminals are using voice alarms (via public address system), also referred to as textual alarms. They often provide information on what to do in an emergency.

Textual alarms are usually the principal evacuation signal. In the absence of visible textual alarms, persons with hearing impairments have to know that audible instruction will occur, what the potential messages might be, how to tell from observation, question, or pre-planned assistance what the message was, and how to execute the instructions.

Some issues concerning the use of audible alarms are:

- The penetration of an audible alarm is based upon its intensity relative to background noise and its frequency content. But virtually no effort has been expended toward standardizing these warning sounds.
- The continuous bell, tone or siren is the most common type and can achieve any specified intensity, but much of the frequency spectrum is outside the 500 to 2000 Hz range of typical hearing aids.
- At times, the high frequency and high intensity of these alarms interfere with critical communication of instructions and can hinder navigation and orientation of the vision-impaired. Often the first action priority is to turn the alarm off (15).
- Non-continuous voice alarms, either taped or live, can be used to alert without startling and have a greater frequency content. While they may interfere less with navigation and communication, voice alarms may not be sufficiently distinct from panic background noises.
- The information provided by textual alarms increases the level of confidence of the persons threatened by the emergency that they are safe and help is at hand (16).

A unique modification of the textual audible alarm uses a building's telephone system as the communications medium rather than a broadcast message. While this could incorporate TTD's, the concept isn't applicable to transient terminal or vehicle occupants.

Visual Alarms

Visible signalling devices are available from specialty manufacturers serving the deaf community and from general alarm manufacturers. Residential alarms include some integral smoke detectors, but also include innovative devices which transmit information from a detector to a remote lamp by radio frequency, electrical carrier or sound. In addition to a flashing light, a vibrator may be used as the signalling device. In recent years, several large hotel chains in the North America have started to provide visible alarms to guests with hearing impairments. As a consequence, mainstream manufacturers have begun to enter this market area (see Exhibit 9).

AUDIBLE ALARMS

MANUFACTURER	MODEL NUMBER	DESCRIPTION	DB'S @ 10 FT.	PUBLIC/PRIVATE USE	COST/UNIT
AUDIBLE ALARMS					
Pyrotronics	BDC-624	6" vibrating horn	87	Public	n/a
"	CDC-24	vibrating chime	80	Private	$225
	SEA-1	horn	110	Public	n/a
Wheelock	31T-115-R	horn	95	Public	n/a
"	ES-BHI-R	electronic signal	96	Public/Private	n/a
Federal Signal	VALS	horn (1.5W)	93	Public	n/a
Edwards	340-6	vibrating bell	92	Private	n/a
"	879EX	vibrating horn	100	Public	n/a
"	5523	electronic siren	112	Industrial	n/a
"	315A-AH	industrial siren	109	Industrial	n/a
Simplex	2901-9081	single stroke bell	75	Private	$225
"	31X	explosion proof horns	101	Industrial	n/a
"	2901	horn	87	Industrial	n/a

SOURCE: "Alarms Documentation Project" by Applied Concepts Corporation, 1986.

Exhibit 8: Audible Warning Alarms

Visible signalling devices that are to be integrated as part of a general alarm system are the domain of the major manufacturers of alarm systems. A variety of components are available with a variety of colours, intensities, and types of lamp. These devices serve as components for industrial alarms as well as for general alarm systems. Most available devices flash at a rate of 0.5 to 2 Hertz (flashes per second). Their principal use, however, is as supplementary alarms, placed at exits only. For example, the recent design standards (7) for airports state that a visual emergency alarm consisting of electrically powered, internally illuminated emergency exit signs that flash at a rate of 1 Hertz (60 flashes per minute) in conjunction with audible emergency alarms should be used.

Some issues concerning the use of visible alarms are:

- certain frequencies can trigger photosensitive epilepsy, but this is not a well-researched phenomenon.
- the best location to maximize visibility may not be high on a wall where it can be obscured by rising smoke, but close to the floor.
- proper selection of colour is required to minimize smoke scattering yet maximize the connotation of danger.
- people are less familiar with the use of lights and are less liked to interpret them as a danger signal; hence, the use of lights requires user orientation.
- if the light is strong enough to be visible in a typically brightly lit building, will it stun people in the dim light of a fire emergency.
- general system specifications: colour, intensity, duration and placement are based upon the judgment of fire safety professionals rather than research data (16).
- coded flashes can be used to indicate different emergency situations.
- textual information can be given in conjunction with the alarm by incorporating a flashing sign (e.g. exit) or video display.

Sensory Alarm

Typical of this type of alarm are radio controlled tactile communicators (vibrators). While the pagers operate on a broadcast signal they are generally building specific due to the lack of standardization of equipment and signals. Further, each individual must physically possess a complex piece of equipment and be trained in its use and interpretation.

Thus vibrating alarms are assessed at a low effectiveness (16) although the Smith-Kettlewell Eye Research Foundation is developing a wrist-worn vibrotactile multiple alarm for the deaf and the deaf-blind. In addition to its small size, a major advantage is the incorporation of a system of codes which allows the user to interpret which alarm is activated.

VISIBLE ALARMS

MANUFACTURER	PRODUCT NAME	TYPE OF LIGHT	COLOUR OF LIGHT	FREQUENCY OF FLASH (flashes/sec)	INTENSITY (1000 peak candlepower)	COST/UNIT
COMBINATION SMOKE DETECTOR/VISUAL						
Genfex	7102	strobe	white	1-1.5	30	$150
Whelen Engineering Co. In.	Strobe Alarm	strobe	white	1.25	1000	n/a
VISIBLE ALARM-REMOTE RECEIVERS						
Sound Barrier, Inc.	Lifesaver	strobe	white	adjustable	n/a	n/a
Sonic Alert	Sonic Alert System	incandescent	white	n/a	n/a	n/a
Nationwide Flashing Signal Systems Inc.	Strobe Alarm Detector	strobe	white	n/a	n/a	n/a
Nationwide (used with incandescent lamp)	MicroLert	incandescent	any bulb	n/a	n/a	n/a
VISIBLE ALARM - HARDWIRED						
Kidde Automated Systems Inc.	AV-32S, V-33S	strobe	white, red	1	10	$165
Pyrotronics	AV-32, V-33	incandescent	white, red	1	2.5 candlepower	n/a
"	Series HS and SV	strobe	white	1-3	8	n/a
Wheelock	various models	strobe	white	1	70	n/a
"	various models	strobe	white	1	80	n/a
Federal Signal Corporation	400F, 400R	incandescent	various	1	5	n/a
"	400ST	strobe	various	1.25	400 candlepower	n/a
Faraday Fire Alarm Systems	Fara-Mod Strobe Horns	strobe	white	1-1.5	25-95	n/a
"	Fara-Mod Strobe Devices	strobe	white	1-1.5	25-95	n/a
"	Fara-Mod Bell/Chime Strobe	strobe	white	1-1.5	25-95	n/a
Simplex	2903 series	incandescent	various	1-3	8	n/a
"	2903 series	strobe	various	1-3	8	n/a
"	2904 series	incandescent	various	1-3	8	n/a
"	2904 series	strobe	various	1-3	8	n/a
Edwards	AdaptaBeacon Rotating Lights	incandescent	various	1.5	n/a	n/a
"	AdaptaBeacon Strobe Lights	56 series strobe	various	1.3 (double)	1025	n/a
"	AdaptaBeacon Strobe Lights	90 series strobe	various	1.08	1000	n/a
Julian McDermott Corporation	Puls Life	strobe	white, red	1	800-1000	n/a
Thomas Industries of Canada	Vis-alert	strobe	various	n/a	n/a	n/a

SOURCE: "Alarms Documentation Project" by Applied Concepts Corporation, 1986.

Exhibit 9: Visual Warning Alarms

COMMUNICATION AIDS

Communication aids, especially with the hearing, sight and perception impaired passenger, is extremely important. In an emergency situation such as on-board an aircraft, many able-bodied persons experience some hearing difficulty and would benefit from visual aids as well. Exhibit 10 illustrates some of the aids that are available.

Standard travel communications provide the traveller with initial facility orientation and safety information, such as location of exits, emergency equipment and emergency procedures. Initial, but incomplete, steps have been taken by the airline industry to assist the communications impaired person -- such as close captioned video aircraft displays and braille seat-pocket information cards.

Emergency and alarm communications provide a dramatic contrast to orientational communications. Here the prime need is to clearly signal the presence of danger and issue emergency instructions. After the initial alarm, rescue personnel -- especially transportation company employees -- must communicate to build a fundamental level of confidence with the disabled person. Frequently, it is difficult for company employees to motivate travellers to follow emergency procedures.

Professions dealing with persons having communication disorders have a tendency to 'normalize' their subjects. Bliss symbols, eyepoint boards, computers, etc., are all attempts to restore some form of communication. Many travellers, coping with their communications disability, utilize their own personal form of communications aid. These vary from preprinted information cards to computerized voice synthesizers which provide slow communication on the order of a few words per minute. The usefulness of these techniques in an emergency is doubtful. If is clear that persons who require special devices to understand messages will have considerable difficulty in an emergency, if messages are given in a medium not compatible with the user's device.

The best approach for individuals with communication impairments appears to be through a set of verbal and gestural messages and instructions, supported by eye contact, body contact and other props such as signs indicating the fire or other emergency. Using these procedures should: (1) Alert the rescuee that there is an emergency, (2) Establish the rescuee's trust in the rescuer, and (3) Allow the rescuer to size up the needs and capabilities of the rescuee (16). For this reason, attempts have been made at teaching police and firefighters basic American Sign Language signs but no evaluation of these attempts seems to have been made.

Communication of information before and during an emergency is a key to disaster-coping behaviour (5). In time of critical crisis, any inhibition of immediate action, such as communicating instructions, is not acceptable.

COMMUNICATION AIDS

TYPE OF AID/MANUFACTURER	PRODUCT NAME	DESCRIPTION	PERSONAL OR PUBLIC AID	REQUIREMENTS	COST/UNIT
AIDS FOR THE BLIND OR SIGHT IMPAIRED					
Loop System		Provides Info on Signs	Personal	Transmitter	$100 per receiver
Radio System		Provides Info on Signs	Personal	Transmitter	$100 per receiver
Infrared Light System		Audio Navigation Info	Personal	Transmitter	$100 per receiver
Love Electronics Incorporated	Talking Signs	Infrared Light System	Personal	Transmitter	n/a
Sennheiser	Talking Signs	Infrared Light System	Personal	Transmitter	n/a
Elevator Floor Announcer		Audio Orientation Info	Public	Voice Module	$3500-$7000
Kinematics Research Incorporated	n/a	Talking Elevator Module	Public	Voice Module	n/a
Automated Telephone Information		Public Telephone Info	Public	Central Computer	$100,000
Audio Navigation		Audio Navigation	Personal	Receiver	n/a
Brytech	Sensory 6	Ultrasonic Radar	Personal	Receiver	n/a
Commetrics	Acoustical Finder	Infrared Light System	Personal	Receiver	n/a
Tactile Navigation		Tactile Maps	Personal	Graphics Design	$1.00 per map
Gilligan Tactiles	Generic	Tactile Maps	Personal	Graphics Design	n/a
Braille Computer Output		Braille Computer Output	Personal	Computer	$4000 and up
Maryland Computer Services	Perkins Brailler	Computer Interface Brailler	Pesonal	Computer	n/a
Triformation Systems	MB2400 Microbrailler	Wordprocessor-Brailler	Personal	Computer	n/a
Telesensory Systems	Viewscan	Wordprocessor-Brailler	Personal	Computer	n/a
Visual Amplifiers					
Commetrics	Apollo Amplifier	TV Screen Amplifier			
Wormald International Sensory Aids	Viewscan	Electronic Magnifier	Personal	Computer	n/a
AIDS FOR THE DEAF/HARD OF HEARING					
Standard Signage		Fixed Visual Information	Public	Graphics Design	$100 and up
Visual Paging		Changeable Information	Public	Display Boards	$1,000 and up
Electronic Signs		Changeable Information	Public	Digital Displays	$1,500 and up
Asinc Incorporated	Airshow 100	Digital Info Display	Public	Video Monitors	n/a
Sign Language		Visual Communication	Private	Standardization	Training Costs
Hearing Aids		Audio Enhancement	Private	Personal Device	$250 - $300
Sennheiser	Audio Amplifier	Audio Enhancement	Private	IR Transmitter	n/a
Paper and Pencil		Visual Communication	Private	Paper/Pencil	negligible
Preprinted Cards		Visual Communication	Public	Graphic Design	n/a
Electronic TDDs		Visual Telephone Device	Private	Telephone	$350
AIDS FOR SPEECH IMPAIRED TRAVELLERS					
Artificial Larynx		Speech Enhancement	Private	Electronic Device	$55 and up
Electronic Displays		Visual Communication	Private	Computer Device	$500-$1000
Canon Limited	Communicator	Wrist-Mounted Printout	Private	Computer Device	n/a
Northern Telecom/Bell Canada	Visual Ear	Keyboard/Screen Display	Private	Computer Device	n/a
Medelec Limited	Splink	Wordboard/TV Display	Private	Computer/Monitor	n/a
Prenthe Romick Company	Express 3	Liquid Crystal Display	Private	Computer Device	n/a
Synthesized Speech		Audio Communication	Private	Computer Device	$500-$2000
Texas Instruments	Vocaid	Keyboard/Synthesized Speech	Private	Computer Device	n/a
Communications Research Corporation	Omni System	Synthesized Speech/LCD	Private	Computer Device	n/a
Votrax	HandiVoice	Synthesized Speech	Private	Computer Device	n/a

SOURCE: "Communication Aids for Travellers With Sight/Hearing/Speech Disabilities" by IBI Group, 1982 and miscellaneous reports.

Exhibit 10: Communication Aids

Aids for Passengers with Vision Disability

Broadcast Systems. Where overlapping information streams are not a problem, visual information can be simply duplicated in audio forms. However, orientation and safety information can be directly transmitted to a person with a vision disability without the noise pollution caused by a public address system. These systems inform a select group of travellers each utilizing a specialized receiver.

Information for a specific area can be transmitted via audio frequency modulated magnetic field (similar to telephone). The aerial is a wire loop buried in the terminal (or boarding bridge) floor. Only those people inside the loop can receive the notice. However, each loop can only transmit one channel of information.

Infrared light can also be modulated to carry information, then reconverted to audio by the receiver. The light beam is directional hence it can both inform and guide a person because the transmission is only received when the beam is intercepted.

Widespread reception can be achieved by using radio frequency amplitude modulation (AM) or frequency modulated (FM) transmitters and receivers. While radios are non-directional they cover a large area and like a normal radio can transmit many channels simultaneously. The receiver is tuned to the desired channels.

Tactile Systems. Utilizing contrasting tactile materials, safety, and orientation (navigation) information can be obtained through touch. Detectable tactile surface treatments are used in terminals to warn a cane user of an impending stairway, the edge of a transit platform or to create a tactile pathway (17).

Nordair and several American airlines are using Braille and tactile aircraft cabin cards (18) to inform passengers as to location of washrooms and emergency exits on their aircraft. Feedback to the industry has been limited, possibly due to the small number of people who comprehend braille or to the typical lack of attention paid to safety features by all passengers.

While only a limited amount of information can be given before becoming confusing, these cards could be more useful utilizing an industry standard format and offered in conjunction with an audio presentation.

A major increase in tactile information transfer would be achieved using a computerized Braille printer which could store much orientation information and then 'displayed' in Braille when required.

Aids to Passengers with Hearing Disability

One-Way Communication. Refined mechanical electronic variable signage in its various forms can increase the information density of traditional fixed signs. The extra information presented increases their utility to all travellers. One company for example offers a digital display system for on-board airplanes. It is designed to provide in-flight information but could be easily used to also provide emergency information, which would be especially useful with the high ambient noise in an airplane. Again, a uniform signage standard would increase comprehension significantly.

Close captioned video displays are already in use by Air Canada for in-cabin safety orientation. Extending their use to the terminal building for traveller orientation would be a natural extension of the technology.

Two-Way Communication. Two-way communication in a limited way can be conducted via preprinted message card. The Neil Squire Foundation proposed an emergency data card be carried by the traveller to assist rescue personnel (19). This technique could be adopted for use in small vehicles, such as airplanes, where a 'critical message card' could be quickly given to passengers.

Interactive two-way communications has been substantially increased by a variety of electro-mechanical devices. Familiar Telephone devices for the Deaf (TTD's) allow hearing or speech impaired people to communicate by telephone, using a printer or electronic display. Conceptually, similar portable, battery-powered microprocessor devices can be carried by the traveller to translate key strokes into visual messages. While slow, the device can be used to ask questions and receive information.

Aids for Passengers with Speech Disability

Electronic devices have played the key role for speech-impaired individuals. Human speech -- either words, phrases or sentences -- can be digitized, stored electronically and retrieved by key strokes. The user by the key sequence can generate questions and satements in audible form. However, the vocabulary is limited (20).

Unlimited vocabulary can be achieved by creating and reproducing the component sounds of speech electronically, also selected by pressing keys in proper sequence. As yet synthesized speech sounds artificial and is less understandable than digitized speech. Further, greater skill is required to key in the correct sounds. User communication rates are only a few words per minute compared to hundreds of words per minute for normal speech.

As yet these devices while useful for normal traveller communication are considered too slow for communication of emergency instructions (21).

EVACUATION SYSTEMS

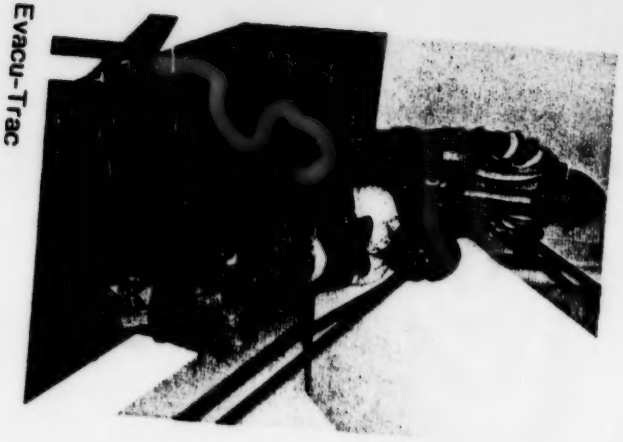
It is reasonable to expect that providing disabled people barrier-free access to buildings will go a long way to enabling them to egress from dangerous areas in an emergency. The most difficult problem with emergency egress is vertical movement in buildings. There are devices available for emergency evacuation of multiple story facilities. None of them are self-operable by a person with mobility impairments. If available for general use, such as an external elevator system, and necessary to save lives, they could also provide for the evacuation of people with mobility impairments, subject to the limitations of their design.

A variety of systems, as shown in Exhibit 11, have recently been marketed as evacuation aids by various companies and inventors, but as yet none are in widespread use. These include roof and window mounted hoists and an external elevator system, designed for general use, and a tracked cart for descending stairways, designed for the assisted evacuation of mobility impaired persons.

Cable Supported. Cable devices similar to ski lifts are useful for evacuating tall buildings. The users secure themselves into a harness which is then hooked to the cable. Descent speed is controlled by automatic braking. Some systems are one-way only while others have a winch to recover the harness. These systems are designed for able people who can put on the harness, attach themselves and exit the building. Window-mounted units usually require the window to be broken while roof-mounted units are useful only to those people who could evacuate to the roof. A disabled or unconscious person could be evacuated by cable systems with the assistance of able evacuees at the top and the rescuer at the bottom.

Track Supported. Building stairwells can be designed to accommodate a set of vertical rails. Lightweight, folding storable transport modules are stationed at each floor. To evacuate, the modules are attached to the rail and descent is by gravity -- but the rider can control the descent speed by handbrake. Attachment of the modules, and descent control requires able assistance, however, the disabled or unconscious person can be accommodated. The idea of a stairway descent device is an attractive one. The physical manipulation which may be required to transfer a persons from a wheelchair to the unit is not a desirable activity, but should be acceptable, if necessary to protect a live.

Fabric Chutes. Fabric chutes are suitable for descent from two or three story buildings. They are stored rolled at the entrance portal and require no cables, harnesses or platforms for use. The chute is dropped to the ground and the evacuee enters feet first. A conscious person with arm usage can control their own descent while an unconscious or disabled person can be placed inside and controlled by the rescuers at the bottom by gathering the chute into their arms to increase sliding friction.



Evacu-Trac

EMERGENCY EVACUATION SYSTEMS

MANUFACTURER	PRODUCT NAME	CABLE STRENGTH	POWER	REUSABLE	OCCUPANCY	PORTABILITY	COST/UNIT
ROOF MOUNTED DESCENT SYSTEMS							
Henke Machine Inc.	Multi-Story Transporter	>4,000 lbs.	Self-powered	Yes	Multiple	None	$30,000
Uniscape	Harness System	4,000 lbs.	Self-powered	Yes	Multiple	Limited	$4,000
Wahlefeld Safety Corporation	High-Rise Rescue Cradle	1,000 kgs.	Self-powered	Yes	Multiple	Limited	n/a
WINDOW MOUNTED DESCENT SYSTEMS							
FIDS	Fire Descent System	1,500 lbs.	Electric/Manual	Yes	Single	None	$1,500
Sinco Products Inc. (ORIRO)	Emergency Descent System	860 lbs.	Manual	Yes	Single	Yes	$690
Rodo Systems Inc.	Slide for Life	2,180 kgs	Self-Powered	Yes	Single	Limited	n/a
Paladium California Inc.	Palladium Slide	n/a	Manual	Yes	Single	Yes	$100/Foot
STAIR DESCENT SYSTEMS							
Garaventa, Ltd. (Emer. Evacuation Chair)	Evacu-Trac	n/a	Manual	Yes	Single	Yes	$1,295
" (Fixed Wheelchair Lift)	Stair Lift	Guide Rails	Electric	Yes	Single	None	n/a
" (Portable Wheelchair Lift)	Stair Trac	n/a	Battery	Yes	Single	Yes	n/a
Designed Devices Inc.	Evac + Chair	n/a	Manual	Yes	Single	Yes	n/a
TUNNEL EVACUATION SYSTEMS							
Washington Metro Area Transit Authority	ETEC	n/a	Manual	Yes	Single	Yes	n/a

Exhibit 11: Evacuation Devices

Fire Safe Elevator. Normal elevators even with over-ride devices on the door open/close and floor selection controls can't be used in a fire without a respirator because the shafts (and cars) fill with smoke and toxic gases. The use or attempted use of elevators in an emergency has caused many fatalities. Experience has shown that the effects of fire and smoke on the operation of automatic elevators is unpredictable. However, recent changes in elevator system design suggest that elevators can be useful mechanisms for vertical egress in fires. In this case, the elevator is taken out of service and returned to a selected floor upon initiation of the emergency signal. Elevators can then be operated by emergency personal with a key from inside the cab. The National Research Council is also attempting to design a fire-safe elevator -- elevators with smoke proof sealed doors and pressurized shafts to protect the occupants. The elevator lobby, if protected by folding fire curtains, could become a holding and refuge area for those waiting to enter the elevator. However, the inability of the building occupants to distinguish between fire safe and standard elevators could lead to much confusion, if not disaster.

Rescue Carts. Horizontal evacuation is probably most difficult in urban transit systems. Simulated evacuations by transit properties have used tunnel rescue carts pushed along the rails that can both bring in gear and evacuate stretcher and wheelchair persons threatened by the emergency. It was noted that modern underground station design includes dedicated access tunnels for firemen, permanently-stored fire fighting equipment, zero fireload design and a highly developed communications system to contact and guide the passengers.

Other Aids. In a crisis situation, any occupant of a terminal or vehicle may require physical evacuation assistance. Several lifting and carrying techniques have been evaluated for emergency evacuations (16):

- any type of lift in which one person carries another can be hazardous to both the rescuer and rescued depending upon their relative weights, rescuer strength, and rescued strength.
- two person lifts while sharing the weight load greatly increases the co-ordination difficulty to the point that stair descent becomes hazardous to all involved.
- dragging the patient on their bed mattress is the recommended mobility technique in hospitals (22). While providing less protection against bumping injury, blankets or coats can be substituted. The weight of the rescuee and the strength of the rescuer become less critical problems in the dragging techniques. However, the rescuer must walk backward -- difficult on a flat floor, hazardous on stairs.
- two people can carry a sedan chair device easily along a hallway, however, descending stairs puts two-thirds of the total weight on the lower person. The weight of the evacuee is then limited by the strength of the rescuer and the distance to be travelled.

- controlled descent chairs with stair spanning tracks and braking devices are designed for use by one person and allow more tolerance in the rescued weight and rescuer strengths. The design of the stair (carpeted, concrete) is a critical factor on the tracks. Getting the evacuee in and out of the rescue chair is a major task often requiring assistance from a second rescuer.

6. PRACTICES

Emergency measures and practices for evacuation of elderly and disabled from transportation facilities includes: evacuation planning and exercises. emergency rescue personnel that can provide assistance, and emergency information briefings.

Increasing attention is being given to planning for emergencies. Emergencies by their very nature are events that cannot be dealt with by ordinary methods or routines, but the idea is to plan to reduce the consequences and perhaps avoid a number of these types of events. One could almost argue that an emergency situation arises as a result of a lack of planning and lack of anticipation.

The problems that emerge in emergency situations are usually those of communication, coordination, information gathering and mobilization. Communication and information exchanges between passengers, transport personnel and emergency officials often breaks down. Coordination among various organizations with emergency responsibilities is often confused. Collecting information on the emergency situation and the results is another problem. It is critical that monitoring be done for effective decision-making. Finally, resources and personnel must be mobilized effectively and this requires correct identification of patterns of behaviour and planning efforts.

Planning has to be based on knowledge. It has to be based on what people will do in an emergency rather than on an effort to force them into conformity with a plan. Emergency information briefings are an important aspect in that they provide information that will tell both the planner and the passengers what will happen in an emergency.

EVACUATION PLANNING

Management must be aware of and concerned with conditions of emergency hazards. It must assume the responsibility to acquire knowledge, develop plans, and implement actions which specifically address the needs of elderly and disabled persons, their strengths and limitations, in matters affecting their safety during times of emergency. This responsibility primarily includes, but is not limited to, evacuation plans. In planning for and implementing the use of evacuation plans, several needs can be identified:

- priority of movement of building or vehicle occupants
- specific evacuation routes and alternate routes (horizontal or vertical evacuation), as well as exits
- the appointment of floor monitors or crew members to monitor safety conditions and direct exercises
- means of self protection (e.g. areas of refuge)
- in-house monitoring of safety hardware and systems
- graphics for denoting escape routes
- notification of building or vehicle occupants
- notification of emergency (fire, police, ambulance) personnel.

Implementation of building emergency evacuation plans must be accomplished through performance of regular evacuation exercises. All building or vehicle occupants, including those who are handicapped, must be included in evacuation exercises in order to promote appropriate emergency response. Evacuation exercises familiarize personnel with the path to the area of safe refuge, whether vertical or horizontal. Rescue personnel must occasionally be consulted in re-evaluating the effectiveness of such plans.

EMERGENCY PERSONNEL

Assistance in an emergency situation will come from three basic sources:

The professional rescuer (fireman, police or coastguard) is highly trained, motivated and well-equipped. They are few in number, however, relative to the number of passengers in a vehicle, they must be dispatched to the accident scene, and their training might not include the detailed procedures specific to each type of vehicle.

Company employees are trained to a varying degree depending upon government regulation and company attitude and resources. In most cases, these employees are vulnerable to injury themselves. This is particularly acute in paratransit where the driver (usually the only able-bodied adult on the vehicle) can be readily injured in a collision.

The volunteer is a fellow passenger or by-stander volunteering to help. With little training or experience, they can be a hindrance as well as a help. During the first few critical minutes, they may be the first help available and must utilize the communication and mobility aids on hand.

The efforts of all three types of emergency personnel should be planned for and coordinated.

EMERGENCY INFORMATION

The need to provide vehicle orientation and safety information equally to all passengers places a major demand on the vehicle communication system. At present, these briefings are most intense in aircraft. Each airline is responsible for designing their briefing and choosing the means to deliver it -- live demonstration or video, with or without close captioning, possibly augmented by Braille seat pocket information cards and tactile orientation diagrams (18). Unfortunately, no industry-wide attempt at standardization has been made. Even the efforts to inform the visually-impaired passengers through Braille cards are not consistent in format or content.

Oral briefings are often given prior to takeoff and usually consist of information on oxygen masks, seat belts, briefing cards and the general location of emergency exits. In many cases, the oral briefings are given live; one flight attendant recites the information over the public address system, while the other flight attendants in the aisle demonstrate certain actions in concert with the oral briefing.

A serious problem exists regarding aircraft cabin briefings in that the demonstrations are neither capturing nor holding passengers' attention (23). In general, passengers don't acknowledge the live demonstration, watch the video, read the seat back cards (including the Braille version) or inspect the exit locations. For whatever reason, the major concern still exists -- how to really inform passengers about airplane safety features and procedures? Similarly, shipboard safety announcements are often ignored.

In part, the response by airline and ferry management has been intense crew training. Each crew member has rehearsed designated task for each type of emergency. Strong emphasis is placed on crowd control and organization of evacuation procedures. Thus the crew takes the place of communications aids, alarms, emergency instructions, announcements, and passenger familiarity with the airplane or ferry.

Rail, transit and bus passengers present a different challenge to the safety planner. These passengers are highly transient and occupy the vehicle for a relatively short time. No serious attempt has been made to provide safety briefings and orientations. While the opportunity may not be present, the need certainly is.

REPRESENTATIVE PRACTICES

Interviews with knowledgeable operating personnel in Canadian Airlines International, Air Canada, B.C. Ferries, B.C. Transit and Via Rail were undertaken to form a picture of typical planning and emergency procedures prevalent in Canada's transportation industry.

These interviews must be interpreted carefully because no two companies operate in the same manner. For example, the design and operation of each of Canada's major airports is unique, hence their emergency procedures are also unique.

Nonetheless, the interviews represent a significant compendium of expert opinion and provide worthwhile mode-specific comment.

Aircraft

In-Cabin Safety Orientation. Each airline is responsible for designing their own cabin safety briefing and choosing the means of delivery -- in person or using a video presentation. While a large airline would have uniformity within the company, no organized standardization exists amongst the world's airlines. As a commercial venture, an American company designs and prints seat pocket safety cards for 30 airlines. Again, uniformity is a problem due to the custom features of similar aircraft.

Enhancements of the traditional live safety demonstration include close captioned video briefings by Air Canada and braille seat pocket cards by Nordair and several U.S. airlines. These are worthy changes, however, only a small fraction of the visually-impaired people in Canada can read braille. Similarly, the number of people using sign language is also small. Perhaps a special audio briefing could be made on the entertainment system, and textual video supplement the signing.

A serious problem exists regarding cabin briefings (23,24) in that the demonstrations are neither capturing nor holding the attention of the passengers. In general, passengers don't listen to the live demonstration, watch the video, read the seat back cards (including the braille version) or inspect the exit locations.

Whether the passengers don't want to recognize the risks inherent in any travel or they have a high degree of faith in the security of air travel, a major question still exists -- "How to really inform passengers about airplane safety features and procedures?".

Air Crew Training. In part, the industry response has been a high standard in aircrew training. Based upon drills, simulations and classroom lectures, each crew member has learned their role in handling aircraft emergencies.

The passengers are not expected to actively participate. On a specific emergency situation, all information is assessed and the course of action decided before the passengers are notified using the public address system (or loud hailer as backup). Thus both the alarm and emergency instructions are given directly by the cabin crew.

Aircraft Evacuation. To obtain aircraft certification, the manufacturer must demonstrate that all passengers can be evacuate within 90 seconds using only half of the available exits ('90-Second Rule'). The United States Federal Aviation Administration (FAA) has shown by evaluating aircraft accidents that anyone remaining in the aircraft beyond 90 seconds has a reduced chance of escape and survival.

The emergency environment changes so quickly that only well-trained cabin crew can assess the emergency, direct passengers to the proper exits (exits near a fuel fire must be avoided), operate the exit and deploy the evacuation slides. While panic must be avoided, rapid action in the first few seconds is imperative.

Seating Policies. In most transport modes -- ferry, bus, train, and small aircraft -- the choice of seating location is left to the individual. Large aircraft, however, have controlled seating. This necessitates definite seating guidelines and inevitably leads to controversy.

In 1977, the United States Federal Aviation Administration studied the problem extensively using a tiltable aircraft evacuation simulator and presented several significant observations (2):

- paraplegics lowered themselves to the floor while holding the armrest or merely fell to the floor and then crawled to the exit. Had the tests continued onto an escape slide, these subjects would have required to turn around to avoid entering the slide headfirst.
- the male paraplegic, because of his size (210 lb) found that he must move sideways down the aisle. He became exhausted after moving past three rows of seats.
- blind subjects indicated that they used the interrupted seat spacing to tell when they had reached exit accessways while moving down the aisle. Few made a point of counting or remembering numbers of seat rows to exits.
- assisting disabled passengers in an aircraft cabin is difficult because of space limitations generate by the seat configuration. Fixed armrests, restrictive seat pitch (distance between similar points on seats) and restrictive aisle widths made assistance difficult and interfered with movement.
- passenger congestion interfered with assisting handicapped subjects.
- assistance in operating the seatbelt was necessary for most subjects.

- some elderly subjects, particularly those easily confused and those lacking mental retention ability required additional instruction.
- analysis of movement from the window seat to the exit indicates that subjects expended up to 50 percent of the total time in moving from the window seat to the aisle. Thus, it appears that an advantage would exist for the handicapped passenger seated in an aisle seat rather than a window seat.
- canes, crutches and similar aids did not improve escape times in the tests.
- the average ambulatory handicapped passenger appears to possess adequate mobility for escape. He could be seated anywhere in the cabin except in a exit row or a primary over-wing exit route.
- non-ambulatory passengers requiring assistance were more efficiently aided when seated away from the congested exit areas. Seating of two non-ambulatory passengers both of whom may require assistance during an emergency evacuation, across the aisle from each other could result in interference as assistant attempt to move the handicapped individuals into the aisle.
- if non-ambulatory passengers are seated in a group, the group should be seated in the cabin so that they and their assistants would be at the end of a line of evacuees so as to not interfere with the evacuation of other passengers and to avoid crowding by other passengers during their preparation for evacuation.

The seating procedures for the disabled especially the exit row issue continues. "In the case of emergency evacuation the placement of such passengers is crucial. If they are at the exit there is the possibility of hindering the fast flow of the general passenger load in exiting. If, on the other hand, they are seated too far from the exit, personnel must lose time (which may not be available) in getting them to an exit. Yet, in actual emergency evacuations, one or more exits are not operational. Further passenger panic seems to be the norm rather than the exception. [Editor: This statement is contradictory to most of the published evidence]. The emergency evacuation of disabled groups needs to be studied and effective exit procedures developed under such conditions" (25).

To handle this situation, Transport Canada has adopted guidelines for the maximum number of non-ambulatory passengers that may be safely transported on any flight. While these numbers are based on the research by the Aeromedical Institute of the U.S. Federal Air Administration, they take into account the type of aircraft, availability of controlled seating, whether the non-ambulatory passenger is accompanied by an attendant, potential assistance from fellow passengers and the special abilities of 'wheelchair athletes'. While the numbers have evolved from industry consultation and have achieved a considerable degree of acceptance, they can still be criticized by various advocacy groups as subjective values.

"This general approach of dealing with evacuation safety problems through the establishment of limits appears to be reasonable. However, the actual numbers and the underlying assumptions should remain under critical reassessment and be open to revision in either direction by Transport Canada" (6).

In order to provide the safest environment for all passengers with equal evacuation opportunity, Transport Canada recommends that anyone lacking agility not sit near certain exits as they are difficult to use and that anyone requiring assistance to evacuate be behind the crowd, where there is space to maneuver, rather than in front. The carriage of guide dogs, both sight and hearing, presents a problem. Quantitative data regarding the dog's behaviour in a rushing crowd is not available to substantiate any decision to permit them in the cabin or not.

A special video presentation has been prepared (26) to help train aircraft cabin crew to provide the safest seating location and to explain the importance of seating to special interest groups, as a way of providing the safest environment for all occupants.

Ferries

Safety Orientation. Once away from the dock, a safety orientation is conducted over the public address system (27). Due to the large internal space in a ferry, there is no assigned seating -- indeed, some passengers continuously walk to the decks. Hence, no printed safety material such as seat cards is available. Similarly, video safety displays are not used.

In spite of first appearances, passengers are not anonymous. All travellers must pass through the toll booth. Bus operators must report their passenger load and drivers of private vehicles voluntarily advise the toll collector. Hence, the chief steward is aware of number and conditions of any disabled persons on each sailing.

If a braille safety card and tactile map of the vessel were available, the toll booth would be an ideal location to dispense such an orientation package.

Crew Training. All ferry personnel participate in a practice drill at least once in every ten day crew rotation which simulates a specific emergency situation. Each crew member has an assigned task. For example, the catering staff is responsible for crowd control with each person assigned a specific location. These crew members are specially instructed in crowd control and organizing the passengers into the necessary procedures. The high level of crew training and emphasis on crowd control is the prime method of assisting passengers who have no concept of shipboard safety procedures.

Emergency Procedures. Shipboard alarms are coded and intended to inform only the crew; for example, a combined bell and ship's whistle is the signal to abandon ship. After the situation has been assessed, action initiated and the crew alerted, the passengers are informed via the public address system. With no visual signal, a deaf person could miss the announcements. Crew members, however, are assigned to circulate all decks and notice andy contra-indicated behaviour. They also inspect all private spaces (washrooms) and all vehicles on the car decks for any person not responding to the announcement.

Passengers are not expected to know procedures or take independent action. Crew members deal directly with the passengers and personally guide their actions.

A potential shipboard emergency -- fire in the car deck -- is a similar situation to a fire in an underground garage. While fire doors will seal off the passenger area, smoke and toxic fumes still present a grave danger and limit the use of internal elevators.

Modern ship design is an important factor in passenger safety. Instead of narrow corridors and many small lounges, contemporary design stresses high visibility -- no corridors and large open spaces. The passenger lounge deck is immediately below the open promenade deck. Thus, while no specific features are designed for the elderly and disabled, evacuation at a terminal (bomb threat) requires descending one flight of stairs while evacuation at sea requires only climbing one flight. The crew (and, likely, passengers) are capable of negotiating one flight of stairs assisting a non-ambulatory person.

Abandoning ship must be accomplished in a maximum of 30 minutes (Coast Guard guidelines). Modern vessels rely on inflatable rafts. These rafts are inflated on deck and loaded with ambulatory and non-ambulatory passengers and lowered from davits. Thus, they are readily accessible to the elderly and disabled.

B.C. Ferry Corporation has devised a ferry-to-ferry transfer bridge by which passengers of a stricken ferry can board a rescue ferry. Using this short aluminum bridge, a ferry can be emptied in 10 minutes while at sea. Now, each ferry carries a rescue bridge.

Ferry Terminals. Ferry terminals are mainly huge parking lots for vehicles waiting to board, as the majority of passengers utilize a vehicle -- either private or public.

From a pedestrian point of view, the terminal presents extremely long walkways from the passenger lounge to the ship. This is not an issue because all elderly and disabled passengers are chauffered directly onto the elevator-equipped vessel.

Because most passengers board by vehicle rather than on foot, the pedestrian terminals are small, open and single-story designed to all applicable building codes. However, no special features are included such as visual alarms and barrier-free design has not been emphasized.

Transit

It is recognized that SkyTrain in Vancouver is Canada's latest rail rapid transit system and the first with automated trains. This is reflected in both vehicle and terminal emergency design and procedures. The bus system, however, is based upon equipment similar to any property in Canada.

Rail Rapid Transit. Some SkyTrain safety equipment is specific to this automated system (10):

- the doors will not open automatically when the train is not in their terminal but there is an outside key for use by rescue personnel and an inside emergency release. However, the doors must be pried open.
- the trains are equipped with smoke and heat sensors which are monitored by computers in the system's central control room.
- if any anomaly is detected, the human controller evaluates the problem and decides on the appropriate procedure.
- to minimize confusion, the initial emergency alarm and specific instructions to the passengers are given by voice from the human controller.

The train evacuation procedures are typical of the rail transit industry. In elevated sections, passengers walk along the guideway in the case of a power failure. With power available, a second train can be stopped alongside and adjoining doors opened. Passengers can then step directly from one train to another. Tunnel evacuation is considered to be the most critical safety issue. Even though the trains are designed with minimum fire loading, smoke, fumes and physical confinement compound the rescue problem. The system controller evaluates the emergency sensor data and decides on the course of action -- which direction to evacuate, smoke removal, dispatch of company personnel and summoning of professional rescue organization.

Every effort will be made to evacuate at a terminal where the car doors open automatically and egress is easiest. If the train stops away form the terminal, rescue personnel unlock the doors starting at the car farthest from the danger.

Tunnel evacuation carts are located in each tunnel. Rescuers use them to wheel in equipment and wheel out non-ambulatory passengers -- both wheelchair users and individuals in stretchers.

Periodic training drills are conducted to simulate various types of emergency on rail transit systems. Six drills have been conducted to date. These drills have not only familiarized company personnel with rescue procedures, they have highlighted some equipment and operational problems:

- a simulated tunnel evacuation with only 1/3 passenger load required 42 minutes for evacuation -- a surprisingly long time. The firefighters breathing apparatus didn't have enough capacity.
- a paraplegic in wheelchair and a partially blind person took part in the test. Terminal security barriers blocked the wheelchair evacuation. Removable barriers have been installed as a result.
- if a fire fills a car with smoke, the passengers must endure until a station is reached. No emergency ventilation such as knock-out panels appear to be provided.
- car doors will not automatically open when not in a station. But an emergency inside release is provided. This must be evaluated to determine if release panel is obvious and accessible, if instructions are clear and what force is required to pry open the door. It is possible that individuals with agility impairments or reading limitations may have difficulty.
- rail transit crosses several police and fire jurisdictions due to specific training and procedures of the various rescue organization -- a real need exists for planned inter-service co-ordination to minimize initial conflicts at an accident scene.

Bus Transit. In addition to the regular front and rear doors, emergency passenger escapes are provided by a knock-out roof hatch and hinged side windows. The drivers first responsibility is to evacuate his passengers and remove them to safety. A fire extinguisher, protected from collision damage is provided to help evacuation and reduce damage. Transit bus drivers have first aid training and company training to familiarize them with a special needs of the elderly and disabled.

The drills and career experience have shown that (10):

- firemen have little experience with bus evacuation.
- many buses have combustible interiors and that even a small fire can quickly grow and engulf the bus.
- evacuation through the side windows is difficult due to the high step-up height, large drops from the window to the ground, the top hinge which tends to keep the window closed and the difficulty in opening these windows from the outside.

Terminals. Contemporary transit terminal design emphasized barrier-free access, non-combustible interiors, and no accessible place hidden from view to minimize criminal activity and bomb threats. Similar to the automated

trains, the terminals have smoke sensors reporting to the computer monitored central control room. Emergency alarms and evacuation instructions are given by the human controller directly over the station's public address system. All terminals have incorporated special high contrast signage and tactile warning strips at the edge of the platform as orientation aids to the visually impaired. Due to the nature of the system, leaving a terminal requires negotiating a flight of stairs. In an evacuation, crowd pressure would be a problem for anyone negotiating these stairs slowly.

The underground terminals are specially designed with firefighting and emergency equipment lockers at each end of the platform. In addition, each station has a tunnel rescue cart which rescuers use to bring in gear to a train stopped away from the station and bring out any non-ambulatory passenger. The capacity of the cart is four stretchers or two wheelchairs. To prevent interference between passengers, evacuating up the stairs and firefighters descending, all underground stations have an extra stairway dedicated to rescue access.

7. ISSUES

During the course of the research on this project, several major issues surfaced that need to be addressed when assessing emergency evacuation procedures, techniques and devices. The issues relate to deficiencies in available data, existing research, applicable technology and devices, applied procedures, personnel training and public education. In this chapter, the issues are discussed in the following paragraphs:

DATA ON EMERGENCIES

In the performance of this study, one of the problems that surfaced was the lack of published and readily-available data. This is a problem that affects the development of codes and standards and the application of technology to the problems of the disabled and it occurs partly due to the lack of information on:

- The nature, causes and effects of emergency situations in transportation terminals and vehicles (although some accident data is available).
- The type and scale of emergencies in transportation terminals and vehicles, as well as preventive actions and response actions.

Such information, if compiled, would help determine the most important safety issues to investigate and the areas most likely to offer cost-effective life-safety investments. However, while the need arises for the compilation of such data, the lack of complete information of this sort should not impede implementation of safety features that available information indicates should be effective. Work should continue to prepare for future emergencies now instead of waiting for their occurrence to confirm theories about their possibility.

CAPABILITIES OF PASSENGERS

Another major problem in assessing current state-of-the-art technology to the problems of elderly and disabled persons occurs due to lack of data on:

- The actual capabilities and limitations of disabled persons, including functional characteristics, that would be needed to cope with emergencies or for which compensating features or devices would be required.
- The number and distribution of disabled persons likely to be found onboard vehicles or in terminals to the degree necessary to determine the size, and quantity of needed protective features, spaces, or devices.
- Factual data, histories, and other information on both the manner in which disabled persons have been injured in an emergency and the manner in which they have managed to cope with emergencies.
- Either the history or rational expectations related to the manner in which the efforts of a mixed population of disabled and able-bodied persons interact with each other or their situational environment in manners that assist or impede the safety of all in an emergency.

Much of the available information on disabled persons is provided in terms of physical or mental disabilities; whereas, to determine necessary safety features for disabled persons, information is needed in terms of primary human response capabilities (sensing, understanding, and responding to the threat or hazard). In particular, there is a need for information on the individual's ability to move horizontally or vertically, the strength that is required for movement and handling doors, the ability to hear and comprehend existing alarm and communication systems, and so forth.

LIMITATIONS OF FACILITIES

Transportation Terminals

Most large transportation terminals are low-rise buildings with one or two administration floors above one or two passenger floors. The transportation oriented floors are large open spaces with many people in close proximity. High capacity access is provided, often with direct external exits on each passenger floor. Transportation terminals with their unique design and usage characteristics present several different building evacuation problems:

- The concept of safe refuge has less applicability in a terminal (28) since the open-plan, low-rise design offers a greater movement potential to disabled persons. Yet the disabilities of some individuals may force them to to seek safety within the building rather than trying to exit.
- The greater movement potential in open-plan and low-rise transportation terminals means that mobility and evacuation aids would have more relevance than, for example, in a typical high-rise office building.

- Vertical movement from upper building floors is a major evacuation barrier for all building occupants. The difficulty and hazard in descending stairs could be reduced by developing evacuation devices, as well as continuing effort to perfect a fire safe elevator.
- Terminal safety orientation and communication of emergency instructions is an issue due to the larger number of transient occupants and the higher level of activity that is found in transportation terminals than in high-rise buildings.
- The location and type of emergency warning systems may hamper or preclude their use by disabled individuals with visual or hearing impairments.
- In many large terminals, emergency service personnel are limited in their ability to identify the presence and location of elderly and disabled individuals in an emergency.

The very openness in a terminal facility which should assist in conveying an alarm and emergency instructions can be dysfunctional when passengers are in queues and don't want to leave their place or don't perceive the potential danger. Nonetheless, visual alarms and talking signs, if they were used, would benefit from the open plan. Emergency evacuation devices, such as the Evac+Chair and the Evacu-Trac, would appear to have considerable applicability in a low-rise terminal. Major terminals, such as an airport, appear to offer an ideal opportunity to test the effectiveness of various alarm, communication and mobility aids.

Transportation Vehicles

Most transportation vehicles (ferries would be the noticeable exception) are designed to make efficient use of the available space, resulting in narrow aisles and closely-spaced seats which hinders evacuation in emergency situations. Body deformation and non-horizontal floors are common occurrences in emergencies involving vehicles and these factors also tend to hinder evacuation efforts. In general, transportation vehicles have the following problems:

- Common to all transit vehicles, but most critical in rail vehicles, is the need for zero fire load interiors, insulation and wiring because the presence of smoke and toxic gases within the vehicle greatly compounds the egress problem.
- In urban transit vehicles, side window evacuation is presently hindered by the high step-over height and top-hinging of the heavy glass, as well as possible body deformation as a result of an accident.
- Paratransit vehicles are often standard vans with significant structural modifications and a greater propensity to overturn in an accident. The power lifts to permit access by wheelchair can form impossible barriers in the event of a power failure or body deformation.

Paratransit services generally use small vehicles. The use of small vehicles necessitates a narrow aisle width and short distance between seats which hinders escape and rescue. Most designs have a full width bench seat across the back, blocking the rear doors. Further these doors usually can't be opened from inside. Wheelchair lifts are installed and, in a stored position, these devices can prevent emergency exit through the door. Removal of the original roof and fitting an extended fiberglass cap can significantly reduce the structural integrity of the vans. The cap can be torn off or the body crushed in a collision, allowing greater crush penetration into the passenger compartment or contributing to the ease of passenger ejection and the jamming of the doors. Transit and paratransit vehicles need to be evaluated in terms of emergency evacuation as a prelude to improved basic design.

In most transport modes -- ferry, bus, train and small aircraft -- the choice of seating location is left to the individual. However, large aircraft generally have controlled seating. There is considerable differences in opinion as to the proper seating policy toward the elderly and disabled. Specific issues are: whether or not the disabled should be grouped in a specific area, seated or not in exit doors and limited in number. If seated at an exit, there is the possibility of hindering the fast flow of the general passenger load, while if too far away, travel to the exit may not be possible. To handle this situation, Transport Canada has adopted guidelines for airplane seating. However, some issues, such as the carriage of guide dogs is still unresolved.

NOTIFICATION OF ALARM

Terminal occupants and travellers are in a highly transient environment where safety orientation is difficult if not impossible. To overcome the lack of initial safety orientation for the large segment of travellers, assistance must come in the form of superior alarms and precise communication of emergency instructions.

An alarm sounding in a terminal presents a complex problem because it doesn't necessarily motivate the occupants to emergency action. Because false alarms are common, people waiting in a queue may decide not to lose their place in line. The architecture of large open spaces may build a false sense of security: people feel that they can see any problem in enough time to evacuate and hence don't respond immediately or quickly.

A simple ringing bell doesn't convey enough information to gain confidence and ensure initial evacuation response. The steady non-coded signal also inhibits communication between the terminal occupants. Alarms need to be developed that warn without startling and don't interfere with communications. Any audible alarm may disorient blind travellers who depend on normal building noises for navigation.

	ISSUES	DISCUSSION
Emergency	LACK OF DATA ON EMERGENCIES	- Lack of published data on number, nature, causes and effects of emergency situations. - Lack of information on type and scale of emergencies and preventive and response actions.
Passenger	CAPABILITIES OF PASSENGERS	- Lack of information on capabilities and limitations of disabled persons in an emergency situation. - Lack of information on number of and distribution of disabled persons in terminals and vehicles. - Lack of information on behaviour of disabled persons in an emergency situation.
Facility (Vehicle or Terminal)	LIMITATIONS OF FACILITIES	- Some disabled individuals may be forced to seek safety within facility rather than exit. Current practices may not provide areas of refuge. - Vertical movement from terminals is a major evacuation barrier. Certain rescue techniques can pose problems in rescuing disabled individuals. - Safety orientation and emergency instructions is difficult to provide in transient environment of a transportation terminal.
	NOTIFICATION OF ALARM	- Appropriate warning systems for individuals with certain disabilities are not in wide use; many types of those that are in use are not standardized.
	EMERGENCY COMMUNICATIONS	- Disabled individuals are often not provided with information needed to evaluate personal risk in terms of their disabilities and the safety measures of the facility. - Public address systems are difficult to understand even by able-bodied persons at the best of times.
	EVACUATION SYSTEMS	- Certain conventional rescue techniques (e.g., the use of aerial ladders, some carrying techniques) can pose problems in rescuing disabled individuals.
Measures	PLANNING OF PROCEDURES	- Some transportation agencies and authorities do not have detailed emergency response plans. - Emergency drills and rehersals is difficult with the transient activities of passengers.
	SAFETY ORIENTATIONS	- Means of presentation of safety orientation information does not help visually and hearing impaired. - The public general has a tendency to ignore safety orientation presentations
	TRAINING AND EDUCATION	- More information needs to be disseminated on the training in special techniques for rescuing individuals with certain disabilities.

Exhibit 12: Emergency Evacuation Issues

Current alarm systems fall short of meeting the needs of disabled persons who have less time to search for and reach areas of safety than do the able-bodied. Signals are not differentiated, and fail to instruct the disabled as to the action to be taken. Any alarm can create confusion. A person with limited vision, unless given adequate instructions, may move toward the emergency situation instead of away from it. This issue of notifying the elderly and disabled passengers of an emergency involves:

- the design and use of better, standardized methods to notify the general public of an emergency situation through the use of auditory, visual, tactile and verbal alarms.
- the education of the travelling public as to the meaning of emergency signals, what to expect and what to do; and
- conveying enough information to each occupant to ensure their decision to act. This decision is critical to the elderly and disabled where reduced chances of escape are weighted against the potential injury of an unnecessary emergency evacuation.

EMERGENCY COMMUNICATIONS

Positive action in an emergency is based upon obtaining and evaluating information about the nature and extent of the problem. Without this understanding, travellers may lack the confidence to carry out even the most basic emergency procedures. The basic issue here is:

- The need for a higher level of information transfer, possibly use both verbal and visual modes, in order to give disabled persons the necessary information about the facility and the situation to assist them in making decisions.

Certain types of disabilities hinder an individual's ability to perceive and evaluate an emergency situation, due either to sensory or mental disabilities, or to a lack of information about the transportation vehicle or terminal. There is a need to develop requirements for emergency communication systems for elderly and disabled travellers and/or for emergency personnel or other persons that will assist them. Communication of information both before and during an emergency is a key to disaster-coping behaviour. In time of critical crisis, anything which inhibits immediate action, such as communicating instructions, is not acceptable.

Technological assistance could come in the form of voice alarms or a computer-controlled emergency evacuation advisor (29) using computerized voice synthesized instructions. This expert system would employ artificial intelligence to sense a potential problem, analyze it, and deliver emergency advice. Yet there is a danger in complexity. In a state of fear, any traveller can fail to understand signals and instruction, fail to remember procedures and fail to overcome physical obstacles.

An additional major deficiency in present systems is that no provision is made for building occupants to communicate with emergency personnel. Alarms are by definition a form of communication; but the communication is essentially one-way, i.e. from the transportation personnel to the travellers. Reverse communications are also important, especially in transportation terminals. The first instance where this is true is external communications to emergency response units for the purpose of reporting the emergency. The second is internal communications to emergency response personnel in the building to notify them of needed assistance. If a person is unable to evacuate due of being cut off from escape by smoke or fire, then the need for communication is extreme.

Emergency communications, where the primary need is to clearly signal the presence of danger and issue emergency instructions, is a dramatic contrast to orientational communications. After the initial alarm, rescue personnel -- especially transportation company employees -- must communicate with the disabled person to build a fundamental level of confidence which allows them to assess their needs and abilities. Frequently, it is difficult for company employees to motivate travellers to follow emergency procedures.

EVACUATION SYSTEMS

Even though numerous building codes, standards and regulation deal with the movement of people within buildings, emergency vertical movement when elevators are not usable or when only steps are provided poses a great difficulty to the elderly and disabled and raises a number of problems:

- While mobility devices are available to facilitate stair travel, their capacity remains low and they may reduce overall crowd flow capacity by lowering the effective flow rate of evacuees.
- In addition to the safety threat of the emergency, the evacuation process itself poses a physical threat to the disabled traveller -- stair descent can injure both the person being rescued and the rescuer.
- Certain conventional evacuation techniques (e.g., the use of aerial ladders, some carrying techniques) can pose problems in evacuating disabled persons.
- Further, emergency ascent from underground garages is totally absent from safety codes.

Traditional elevator standards preclude the use of elevators by either disabled persons or the able-bodied in emergencies. The National Research Council of Canada is investigating the fire safe elevator as a means of resolving this problem. While it is far in the future, the fire safe elevator would permit the egress of all building occupants while protecting them from smoke and toxic gases.

PLANNING OF PROCEDURES

Even with the best emergency equipment and facilities, there is a need for continual disaster planning. The basic issue here is that:

- Detailed evacuation plans for vehicles and terminals for various types of emergencies need to be designed and then kept current and viable by frequent rehearsal (and revision) involving both company employees and professional rescue personnel.

Emergency planning must recognize that an emergency is a social event occurring over time. It is a process considering mitigation, preparedness, response and recovery -- not a product. Detailed evacuation plans for both vehicles and terminals are kept viable by frequent rehearsals involving both company employees and professional rescue personnel.

The travellers themselves are a major uncertainty in any emergency plan. They are transient occupants of the facility and are under severe pressure. Very few passengers have participated in a practice drill or are even aware of the specific emergency procedures for a facility. Thus the planning must stress precise and reliable information and instructions to guide and motivate passengers in an uncertain situation as well as strong and confident leadership from all rescuers.

Planning is further complicated by the characteristics -- and sometimes unknown nature -- of the emergency response units. A transportation vehicle can cross a number of jurisdictions during the course of normal use. Equipment and procedures can vary between the various fire, police and paramedic departments. Evaluation of rehearsal drills can highlight any discrepancies and maximize inter-service co-ordination.

SAFETY ORIENTATIONS

In a particular terminal or vehicle, the quality of the initial safety orientation has a direct bearing on safety in an emergency situation. In an airplane, a person's ability to locate and operate the emergency exit is a function of the quality of the pre-flight briefing.

The issue of passenger attention to safety information is important because there is evidence that passenger safety could be increased if passengers were more knowledgeable of what to do, and when to do it in emergencies. This issue involves the need to:

- Investigate other means of providing safety information that would use communication aids, such as preprinted cards, braille safety cards, and close-captioned videos.
- Standardize mode specific safety orientation techniques to gain reinforcement from repetition and to maximize effectiveness.

- Investigate the content, novelty and complexity of safety orientation information to determine the best means of providing the information so that it is retained by the passengers.

Airlines have put considerable energy into their in-cabin briefing. Special close-captioned video, braille seat cards and tactile layout diagrams are all being used. These aids need to be critically evaluated as to usefulness (format and content) in light of the fact that only a minority of visually-impaired persons read braille and a minority of hearing or speech-impaired are proficient in sign language. Three characteristics of the message which can affect its attention-attractiveness are: (1) it fear-arousing content, (2) its novelty, and (3) its complexity. While content, novelty and complexity have been found to increase attention attractiveness, too much of any of these characteristics can have a reverse effect.

The question of the usefulness of safety briefings is compounded by the difficulty in capturing and holding any passenger's interest during the briefing. It is commonly thought that most passengers aboard commercial aircraft do not attend to either the oral presentation given by the flight attendant prior to takeoff of a normal flight, or to the passenger safety information card located in the seatback pocket in front of the passenger. The braille version of the safety cards tend to be ignored the same as the printed version.

It has been noted that following accidents, some passengers do not seem to know, or are unable to perform, the correct actions to ensure their safety, such as going to the nearest exit, being able to put on the life jacket, using the oxygen mask, etc. Previous research has shown that people who are educated in the correct way to perform these actions, are better able to perform them when required.

It is possible, then, that if passengers were to attend more to the safety briefings, more of them would be able to quickly and correctly perform the behaviour required of them if an emergency were to occur. There is a need, therefore, to investigate alternative means of providing emergency information briefings.

A typical passenger may utilize similar transportation services provided by a variety of companies. But safety briefing and use of communication aids are company specific. That is the quality, presentation, even content vary from company to company. An immediate need is to standardize mode specific orientation techniques to gain reinforcement from repetition and maximize effectiveness.

However, a major uncertainty exists as to the degree to which a safety briefing specific to one vehicle or terminal will be useful in another type of vehicle or terminal. Will residual knowledge from one transport mode be a help or a hindrance in another mode?

TRAINING AND EDUCATION

Training

Training of company operating personnel must continue as a high-priority because these employees are the first line of defense in an emergency. They must possess detailed knowledge of the equipment and procedures of their job gained through frequent rehearsal of terminal and vehicle evacuation procedures. Particular emphasis should be given to paratransit operators who deal exclusively with elderly and disabled passengers yet don't have access to full-time training centres.

In paratransit accidents, "evaluation of methods and equipment currently available for rescue in such situation revealed a number of short comings in existing training, equipment and operating procedures. Standard techniques for rescue from automobiles now serve as the basis for the rescue of elderly and disabled passengers from transit vehicles, yet these procedures are often insufficient" (8).

Fire fighter training, while already significant, should be expanded to include: specific problems and needs of the elderly and disabled, rescue from large transit buses, and rescue form small paratransit vehicles.

Transit and paratransit bus drivers deal with a large number of travellers on a short duration basis. It is these modes that are attracting an ever-increasing number of elderly and disabled users. While the major transit properties usually have full-time training staff available, the smaller systems and custom transit systems do not have this resource to draw on. Due to the nature of the transportation service provided, an enhanced training package needs to be developed especially for the small and custom transit operators. In this case, a video taped package has some significant advantages over a circulating professional trainer. The training aid must be of professional quality to avoid a stilted presentation of stale ideas and to convey a sense of relevance to each bus driver.

A parallel effort would be the production of an enhanced training video series aimed primarily at paratransit operators but suitable for small transit properties as well.

Education

There is a need for public education in the area of alarm systems and disabled persons, directed at both the consumer and facility managers. Because of the regulatory-driven nature of the marketplace for alarm systems, both groups tend to be ignorant of the alternatives involved. Public education and technical assistance is necessary to impact on the marketplace and to effect change. Some transportation system providers might choose to install enhanced alarm systems if they were aware that

the alternative exists, and that certain consumers were interested in these alternatives.

Investigations should be conducted in detail of systems or approaches by mode to permit the widest possible range of flexibility and cost control alternative approaches in achieving life safety objectives for disabled persons. Subsequently, brochures should be developed for both consumers and facilities professionals that describe alarm systems for the disabled, inform the reader of the existence and applicability of textual alarms and communication devices for use in areas of refuge and at stairwells. The brochures should also state the importance of evacuation planning.

8. RECOMMENDATIONS

Based on the information presented, recommendations are presented in the following sections and are summarized below in order of priority. The recommendations are relevant to:

- Investigations, research, and information-generating activities to provide a better data base of emergency situations by mode for future planning, decisions, and actions.
- Investigations, research, and information-generating activities to provide a better data base on the capabilities and limitations of elderly and disabled passengers during emergency situations.
- Research and testing to establish the effective envelope of visible alarm signals and the best audible signal(s) for warning the largest number of people with hearing impairments.
- Research and testing to develop clearly-understood voice alarm systems in conjunction with visible textual alarms for use in any transportation terminal or vehicle.
- Human factors research and analysis of initial safety orientation information for travellers with respect to means of presentation, format and content of the message.
- Human factors research and analysis of emergency communication systems and devices which would allow for emergency notification, provisions of instructions and information, and summoning assistance.
- Improvement of education and training, particularly as it relates to instructional manuals and background materials for both the individual disabled persons, and for those who will be called upon to aid them.

- Investigation of evacuation routes and refuge areas relative to the prompt removal of all persons from areas of immediate danger and eventual removal to areas of permanent safety, including the development of important concepts involving the degree of redundancy of egress paths and staging areas.
- Investigation of systems or approaches by mode to permit the widest possible range of flexibility, cost control and alternative approaches in achieving life safety objectives for disabled persons.
- Pre-planning and development of emergency plans for transportation systems as relates to the individual, the management of transportation services, and other related emergency response organizations.
- Development of codes and standards for elderly and disabled persons as integral parts of general life provisions. There should be no separate life safety codes and standards for disabled persons.

RECOMMENDATIONS

Data on Emergencies

The lack of data on emergency situations by mode is a major problem affecting the development of codes and standards and the application of technology to the problems of evacuating disabled persons from transportation vehicles and facilities. As a result of this issue, it is recommended that:

- Investigations, research, and information-generating activities be undertaken to provide a better data base of emergency situations by mode (including number, nature, causes and effects on elderly and disabled persons) for future planning, decisions, and actions.

Capabilities of Passengers

Another data-related problem is the lack of data on the actual capabilities and limitations of disabled persons, including functional characteristics, that would be needed to cope with emergencies or for which compensating features or devices would be required. It is recommended that:

- Investigations, research, and information-generating activities be undertaken to provide a better data base on the capabilities and limitations of elderly and disabled passengers during emergency situations, such as:
  - Debriefing of persons who were involved in an emergency, particularly elderly and disabled passengers.
  - Crowd flow experiments to evaluate capabilities of elderly and disabled in emergency situations.

	ISSUES	RECOMMENDATIONS
Emergency	DATA ON EMERGENCIES	Investigations, research, and information-generating activities to provide a better data base on emergency situations by mode for future planning, decisions, and actions.
Passenger	CAPABILITIES OF PERSONS	Investigations, research, and information-generating activities to provide a better data base on the capabilities and limitations of elderly and disabled persons during emergency situations for future planning, decisions, and actions.
Facility (Vehicle or Terminal)	LIMITATIONS OF FACILITIES	Development of codes and standards for elderly and disabled persons as integral parts of general life safety provisions. There should be no separate life safety codes and standards for disabled persons.
	NOTIFICATION OF ALARM	Research and testing to establish the effective envelope of visible alarm signals and the best audible signals for warning people with hearing impairments.
	EMERGENCY COMMUNICATIONS	Research and testing to develop clearly-understood voice alarm systems in conjunction with visible textual alarms for use in any transportation vehicle or terminal.
		Human factors research and analysis of emergency communication systems and devices which would allow for emergency notification, provisions of instructions and information, and summoning assistance.
	EVACUATION SYSTEMS	Investigation of evacuation routes and refuge areas relative to the prompt removal of all persons from areas of immediate danger and eventual removal to areas of permanent safety, including the development of important concepts involving the degree of redundancy of egress paths and staging areas.
Measures	PLANNING OF PROCEDURES	Pre-planning and development of emergency plans for transportation systems as they relate to the individual, the management of transportation services, and other related emergency response organizations.
	SAFETY ORIENTATIONS	Human factors research and analysis of initial safety orientation information for travellers with respect to presentation, format and content of the message.
	TRAINING AND EDUCATION	Improvement of education and training, particularly as it relates to instructional manuals and background materials for both the individual disabled persons, and for those who will be called upon to aid them.

Exhibit 13: Emergency Evacuation Recommendations

Limitations of Facilities

Transportation facilities have many factors that warrant special consideration in the development of codes and standards -- not the least of which is the high volume of transient activity. Better codes and standards for these facilities need to be developed and it is recommended that:

- Codes and standards for elderly and disabled persons be developed as integral parts of the general life safety provisions in building codes. There should, however, be no separate life safety codes and standards for disabled persons -- they should be integrated.

In the development of codes and standards, several features of building design which can facilitate emergency evacuation may have to be addressed through additional building research and it is further recommended that:

- Further research of building standards directed to standardization of emergency facilities, evacuation from underground areas and crowd flow experiments be undertaken. Research on standards could consider:
  - Design Uniformity. In, for example, stair and landing dimensions and surface friction coefficients to assist the use of mobility aids. Similar exit locations and markings in all types of terminals would assist travellers to remain oriented in a low-visibility situation.
  - Safe Refuge Areas. Safe refuge areas are not considered applicable to open plan terminal floors but are necessary on administration floors as any office building.
  - Underground Garages. Underground parking garages present a difficult rescue problem. Greater consideration is required of evacuation routes from underground spaces; of smoke and toxic gas control; of the function of sprinklers in case of gasoline-fed fires.
  - Crowd Flow. Crowd flow experiments to evaluate the travel time to exits or safe areas and capacity of halls, doorways and stairways with increasing proportion of elderly and disabled -- particularly if mobility devices such as stair descenders are used.
  - Vertical Movement. Vertical movement from upper building floors is a major evacuation barrier. The difficulty and hazard in descending stairs could be reduced by developing evacuation devices -- slides, chutes or baskets -- both for new design and retrofit, as well as continuing effort to perfect a fire safe elevator.

With respect to transportation vehicles, the major issue that was raised related to transit and paratransit vehicles and it is recommended that:

- Typical transit and paratransit vehicles be evaluated in terms of emergency evacuation as a prelude to improved designs. Common to all vehicles is the need for zero fire load interiors because the presence of smoke and toxic gases within the vehicle compounds the egress problem

Notification of Alarm

In the hectic, transient environment of transportation terminals, safety orientation is difficult if not impossible. To overcome the lack of safety orientation for the large segment of travellers, superior alarms and precise communication of emergency instructions are needed. Alarms need to be developed that warn without startling and don't interfere with emergency communications. Therefore, it is recommended that:

- Research and testing be undertaken to establish the effective envelope of visible alarm signals and the best audible signal(s) for warning the largest number of people with hearing impairments.

The purpose of the research would be to develop standards for the location, frequency and intensity of both audible and visible alarms. For example, there is an apparent need for:

- strobe lights in stairwells to accelerate evacuation by lending a sense of emergency and a sound source located near the exit that would aid the visually-impaired and those blinded by smoke and fumes.
- dual exit lights, one set being installed where it can be seen over the heads of others, and a second set near the floor, which can be seen when there is thick smoke obscuring the upper set.

Emergency Communications

Other communications that are not a part of the alarm system need investigation. Alarms are by definition a form of communication; but the communication is essentially one-way, i.e. from the transportation personnel to the travellers. Reverse communications are also important, especially in transportation terminals.

Without an understanding of the nature and extent of the problem, travellers may lack the confidence to carry out even the most basic emergency procedures. Existing public address systems are often difficult to understand and are of little use to the hearing-impaired. Therefore, it is recommended that:

- Research and testing be undertaken to develop clearly-understood voice alarm systems in conjunction with visible textual alarms for use in any transportation terminal or vehicle.
- Human factors research be undertaken of emergency communication systems and devices which would allow for emergency notification, provision of instructions and information, and summoning assistance.
  - One emergency information system that warrants testing is the use of electronic variable message signs such as those used at sporting events. These may be used for advertising and messages during normal use and could be programmed to provide concise and reliable

information to occupants of terminals involved in an emergency. (Smaller variable message digital displays would also have applicability on board vehicles).

- Another emergency information system that warrants implementation and testing is the use of standard 'critical message cards' that could be handed to individuals with hearing impairments on board vehicles in the event of an emergency. (In some cases, the cards need not be used just for critical messages, but would be of value for any information that is passed from the crew to the passengers, such as information regarding meal service.)

Evacuation Systems

Emergency evacuation when elevators are not usable or when only steps are provided poses difficulty for the elderly and disabled. Certain rescue techniques (e.g., the use of aerial ladders, some carrying techniques) can pose problems in evacuating disabled persons. Therefore it is recommended that:

- Investigations be undertaken of evacuation routes and refuge areas relative to the prompt removal of all persons from areas of immediate danger and eventual removal to areas of permanent safety, including the development of important concepts involving the degree of redundancy of egress paths and staging areas.
  - emergency vertical transport systems both new and retrofit installation, including the firesafe elevator.

Planning of Procedures

Detailed evacuation plans for all vehicles and terminals for various types of emergency need to be designed and kept viable by frequent rehearsal (and revision) involving both company employees and professional rescue personnel. Emergency planning is a continuous, ongoing process. In this respect, it is recommended that transportation administrators consider:

- Pre-planning and development of emergency plans for transportation systems as they relate to the individual, the management of transportation services, and other related emergency response organizations.

The planning must stress precise and reliable information and instructions to guide and motivate passengers in an uncertain situation as well as strong and confident leadership from all rescuers.

Safety Orientation

In a particular terminal or vehicle, the quality of the initial safety orientation has a direct bearing on safety in an emergency situation.

Safety orientations have to consider that not all passengers are able to see or hear the presentation. This is compounded by the difficulty in capturing and holding any passenger's interest in the safety briefing. There is a need is to standardize mode specific orientation techniques to gain reinforcement from repetition and maximize effectiveness.

- Human factors research and analysis be undertaken of initial safety orientation information for travellers with respect to means of presentation, format and content of the message.
  - Efforts to inform the visually-impaired passengers through Braille cards should be standardized so that they are consistent in format and content.
  - Safety information presented in video format on airplanes should include close captioning to appear in the upper right-hand corner.
  - Consideration should be given to possible means of presenting safety information on-board rail and transit vehicles, such as digital electronic displays that may also be used for advertising.

Transport Canada could play a leading role in the passenger briefing problem by researching and producing a series of passenger training videos starting with aircraft safety and evacuation.

Training

Training of company operating personnel must continue as a high-priority. Particular emphasis should be given to paratransit operators who deal exclusively with elderly and disabled passengers yet don't have access to full-time training centres. It is recommended that:

- Improvements be undertaken of education and training, particularly as it relates to instructional manuals and background materials for both the individual dicabled persons, and for those called upon to aid them.

Fire fighter training, while already significant, should be expanded to include: specific problems and needs of the elderly and disabled, rescue from large transit buses, and rescue form small paratransit vehicles.

Due to the nature of the transportation service provided, an enhanced training package needs to be developed especially for the small and custom transit operators. In this case, a video taped package has some significant advantages over a circulating professional trainer. The training aid must be of professional quality to avoid a stilted presentation of stale ideas and to convey a sense of relevance to each bus driver.

There is a need for public education in the area of alarm systems and disabled persons, directed at both the consumer and facility managers. Because of the regulatory-driven nature of the marketplace for alarm

systems, both groups tend to be ignorant of the alternatives involved. Public education and technical assistance is necessary to impact on the marketplace and to effect changes. Some transportation system providers might choose to install enhanced alarm systems if they were aware that the alternative exists, and that certain consumers were interested in these alternatives.

Investigations should be conducted in detail of systems or approaches by mode to permit the widest possible range of flexibility and cost control alternative approaches in achieving life safety objectives for disabled persons. Subsequently, brochures should be developed for both consumers and facilities professionals that describe alarm systems for the disabled, inform the reader of the existence and applicability of textual alarms and communication devices for use in areas of refuge and at stairwells. The brochures should also state the importance of evacuation planning.

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